

50th Annual Fuze Conference

"50 Years of Support Freedom"

9 - 11 May 2006

Norfolk, Virginia

Session I & II: OPENING REMARKS AND KEYNOTE & GENERAL SESSION

- Keynote: Mr. Rene Kiebler, Deputy Project Manager Combat Ammunition Systems, PEO Ammunition
- OSD Perspecctive, Mr. Peter A. Morrison, Staff Specialist OUSD/DDR&E(S&T) Weapons Technology
- PEO Ammo Perspective, Mr. Rene Kiebler, Deputy Project Manager Combat Ammunition Systems, PEO Ammunition
- US Army RDECOM ARDEC Perspective, Dr. Joseph Lannon, US Army RDECOM ARDEC
- Navy Overview, Mr. Steve Mitchell, Ordnance Project Area Director, NAVSEA
- Air Force S & T Strategy, Mr. Timothy Tobik, Air Force Research Laboratory, Eglin
- Air Force Acquisition Strategy, Mr. J. Rick Holder, Sr., Director Fuze Squadron USAF, Eglin
- Fuze IPT Perspective, Mr. Lawrence Fan, Fuze and Microsystem Project Manager, NSWC

Session IIIA: OPEN SESSION

- PGMM, New Application for an Existing Fuze, Mr. Al DeSantis, Picatinny Arsenal, NJ
- Proximity Sensor for the Guided Multiple Launch Rocket System (GMLRS), Mr. Robert P. Hertlein, L3 Communications KDI Precision Products
- Portable Excalibur Fire Control System, Mr Gregory Schneck, US Army RDECOM ARDEC
- Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS), Mr. Tom Walker, US Army RDECOM ARDEC Adelphi Fuze Division
- The Evolution of the DSU-33 C/B Proximity Sensor, A Success in Customer-Contractor Partnership, Mr. Michael J. Balk, ATK Ordnance Systems
- A New Fuze for an Electromagnetic Gun, Mr, Barry Schwartz, US Army RDECOM ARDEC
- Introduction of the Multi Option Fuze Artillery (MOFA) DM84 on 120mm Rifled Mortar, Mr. Jochen Wagner, JUNGHANS Feinwerktechnik

Session IVA: OPEN SESSION

- Challenges Associated with Development of the Affordable Weapon System Fuzing System, Mr. John Hubert, L-3/KDI Precision Products, Inc.
- FMU-139C/B. Electronic Bomb Fuze Design Update, Mr. David Liberatore, ATK
- Shipboard Submunition Fuze Safety and Realiability Enhancements, Mr. John Kunstmann, Indian Head Division, NSWC
- Thermal Battery Development Reduced Product Variability Through 6-Sigma, Automation and Material, Mr. Paul F. Schisselbauer and Mr. John Bostwick, ATK
- Performance Testing of Lead-Free Stab Detonators, Mr. Neha Mehta, US Army RDECOM ARDEC
- TNO Research on EFI's in Relation to Insensitive Munitions, Mr. Wim Prinse, TNO Defence, Security and Safety

Session VA: OPEN SESSION

- Hight-G Mortar Electronic S&A Development and Flight Test, Mr. Cuong Nguyen, US Army RDECOM ARDEC
- Safe Separation Study for MK 437 Mult-Option Fuze for Navy (MOFN), Mr. Brian Will, NSWC, Dalhgren
- Navy Proximity Fuze Simulation with Embedded Tactical Software, Mr. John Langan, NSWC WD
- Inadequacy of Traditional Test Methods for Detection of Non-Hermetic Energetic Components, Mr. Karl Rink, University of Idaho
- Weapons Reliability How Modern Warfare has Changed the Requirement, CDR Tom Hole, USN, US Navy PMA-201
- MAFIS a Proven Hard Target Fuze, Mr. Laurie Turner, Thales Missile Electronics
- Aurora a Proven Hard Target Fuze, Mr. Richard Clutterbuck, Thales Missile Electronics





The Evolution of the DSU-33 C/B Proximity Sensor, A Success in Customer-Contractor Partnership

Wednesday May 10, 2006

Michael J. Balk ATK 763.744.5094 50th Annual NDIA Fuze Conference Norfolk, VA

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"I am always doing that which I can not do, in order that I may learn how to do it."

Pablo Picasso

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Agenda



DSU-33 Overview

DSU-33C/B Development Goals

DSU-33 C/B Design Description

- Approach
- Technologies

Testing Completed

Performance

Questions



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System Description

- Radar Proximity Sensor
- Provides Height of Burst (HOB) fire pulse signal to the fuze for JDAM and GP bombs (FMU-139 & FMU-152A/B Fuzes)

Performance Parameters

- Height of Burst: 5 35 Feet (80%)
- Multiple Weapon Release: 2 or more
- Operational Life: 200 Seconds
- Storage Life: 10 Years

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Circa 1970's a desire arises to improve and combine the performance of the Mk 20 and Mk 43 Target Detectors

DSU-33/B is developed and evolves into the DSU-33A/B



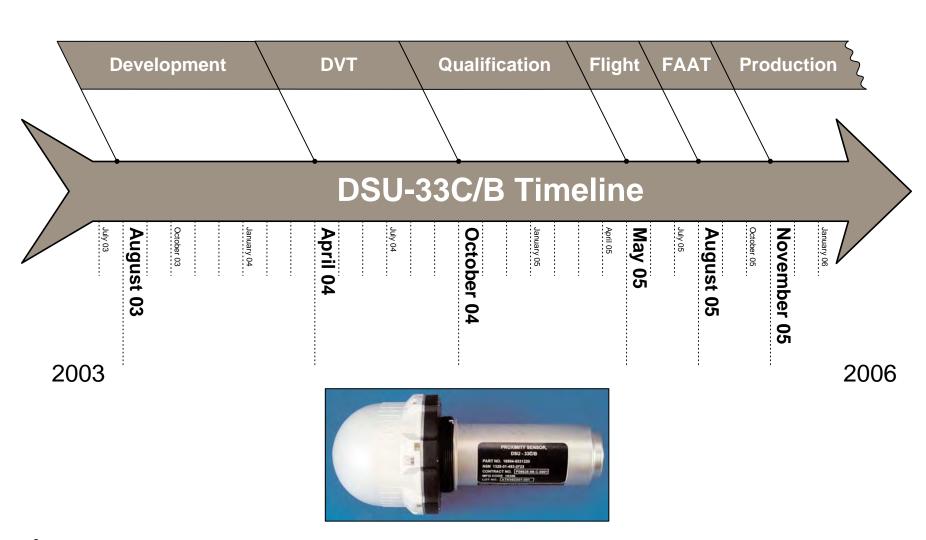
1990-1995 Motorola produced DSU-33A/B's for the U.S. Air Force

1998 DSU-33B/B JDAM design upgrade is completed

2000 ATK begins production of DSU-33B/B's

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DSU-33 C/B Performance ≥ DSU-33 B/B Performance



DSU-33 C/B ICD = DSU-33 B/B ICD



DSU-33 C/B UPC << DSU-33 B/B UPC

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DSU-33C/B Development Objectives



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Address Parts Obsolescence Improve HOB Accuracy Reduce the Material Cost

- Eliminate Parts
- Use Lower Cost Parts
- Lower the Cost of Current Parts

Reduce Labor Cost

- Fewer Parts to Assemble
- Easier to Assemble
- Less Rework
- Less Test Time





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Customer – Contractor DFMA



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When

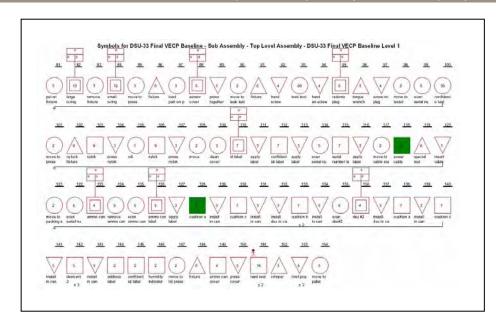
Prior to the PDR

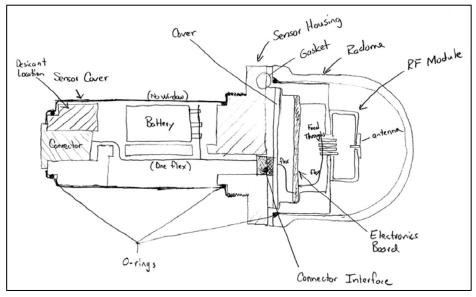
Benefits

- Customer involvement
- Production involvement
- Disciplined look at design approaches and costs
- Cross-functional exchange of ideas

Results

- Improved ease of assembly
- Reduced Material Cost



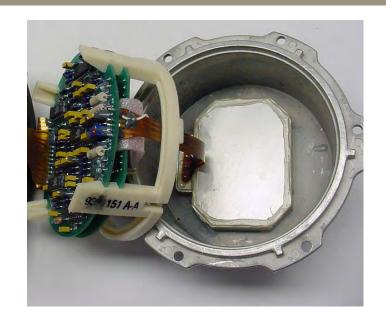


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RF Module Producibility Improved



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- 26 Components
- Discrete Oscillator Design
- Hand Assembled in Electronics Housing



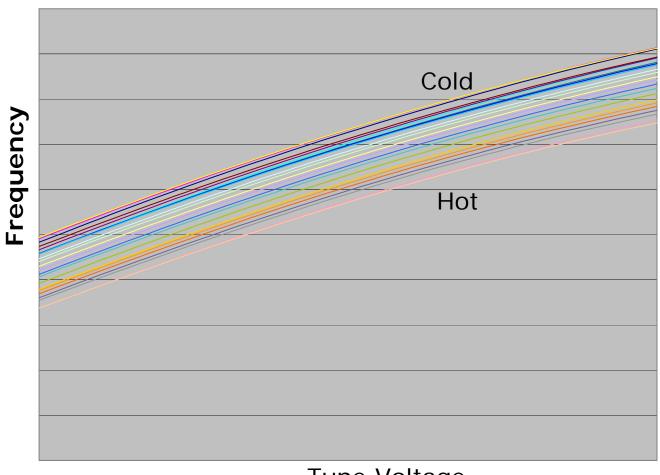
DSU-33C/B RF Design:

- 7 Components
- GaAs MMIC Chip Transceiver
- Removable from Electronics Housing for Solder Reflow Oven

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RF Tuning Curves Over Temperature



Tune Voltage

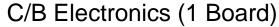
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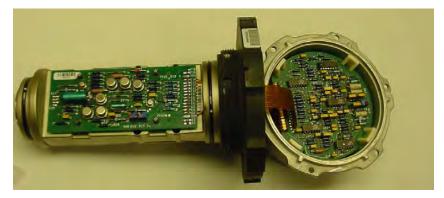
Electronics Reduced to One SM CCA

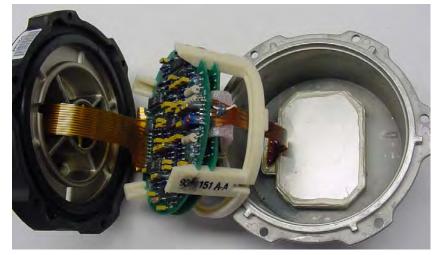


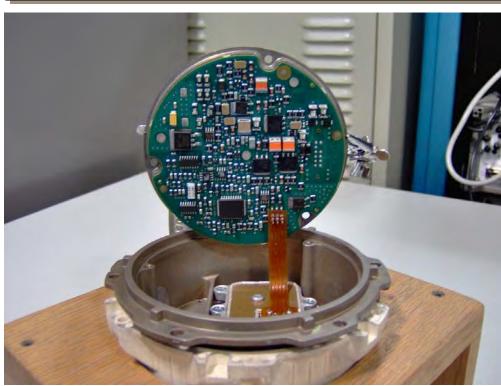
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B/B Electronics (3 Boards)









DSU-33C/B CCA is Manufactured on an Automated Pick-and-Place Machine.

¹² Distribution Statement A approved for public release; distribution is unlimited.

DSU-33C/B Designed for Testablility

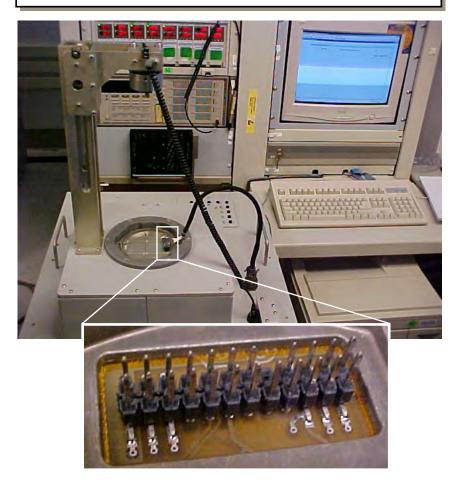


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B/B Test Interface



C/B Test Interface



DSU-33C/B Test Interface is More Reliable and User Friendly.

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Design Verification Testing



Full Contractor Qualification



Flight Testing



First Article Acceptance Testing

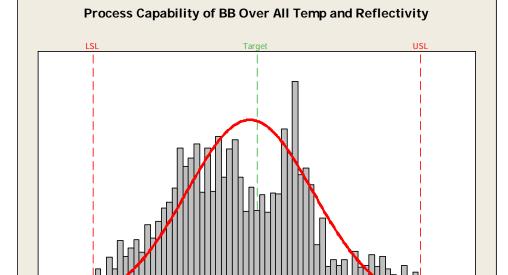


¹⁴ Distribution Statement A approved for public release; distribution is unlimited.

HOB Process Capability



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DSU-33B/B Performance:

- Mean is more than 2.5 standard deviations away from nearest spec limit (Requirement is 2).
- 99.6% Between Limits
- 1,672 Units in Sample

DSU-33C/B Performance:

- Mean is more than 5 standard deviations away from nearest spec limit (Requirement is 2).
- >99.9999% Between Limits
- 1,845 Units in Sample



¹⁵ Distribution Statement A approved for public release; distribution is unlimited.

Process Capability of CB Over All Temp and Reflectivity LSL Target USL



"If you think of standardization as the best that you know today, but which is to be improved tomorrow; you get somewhere."

Henry Ford

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QUESTIONS

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Agenda

- Program Background
- System Overview
- Typical Mission Video
- PGMM Fuze and ETFM commonality
- Fuzing System Design
- Electronics Design
- Summary



Program Background

XM395 - PGMM

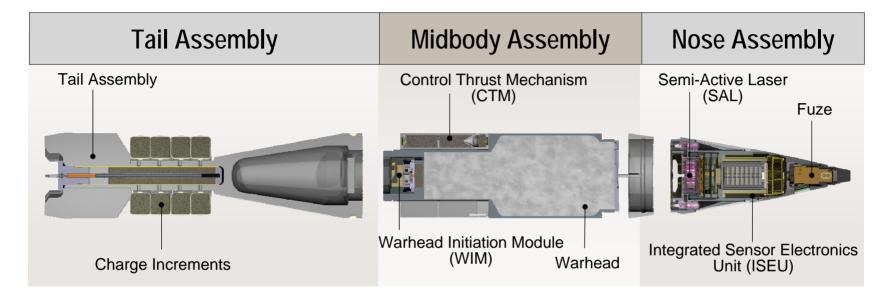


Precision Guided Mortar Munition

Designed to provide point target accuracy against threat targets in urban theater where minimal collateral damage is desired



Program Background



Precision Guided Mortar Munition (PGMM)

- Lethality shall have the ability to defeat or incapacitate personnel protected within specified point targets.
- Range shall be able to engage targets at ranges from 1000m to 7200m.
- Compatibility shall be compatible with all 120mm firing platforms and munition handling systems without adding personnel or equipment to the organization (except for any PGMM-MFCS interface device).
- Reliability shall have a functional reliability of 90% over a 10-year timeframe.

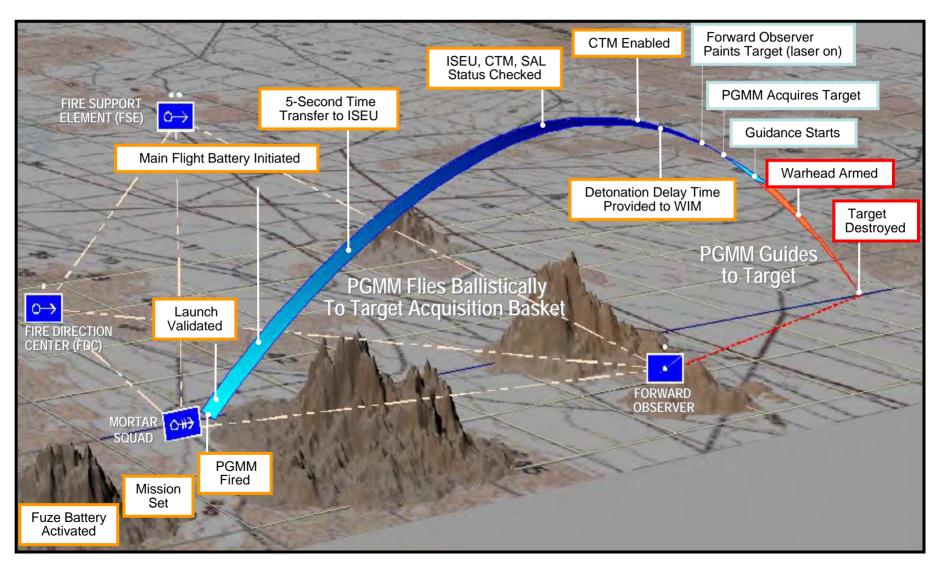


Mission Set Data

- Time of Flight
- Laser Code
- Mode (Delay based on target type)
- QE
- Zone Charge
- Cross Winds
- Downrange Winds



PGMM Fuze Mission Timeline





Typical Mission

Click to start video.

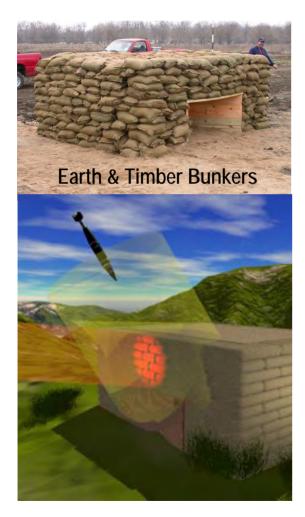


PGMM Key Milestones

- ✓ Contract Award complete January '05
- ✓ System Readiness Review complete March '05
- ✓ Initial Safety Review Board Briefing complete May '05
- ✓ Preliminary Design Review complete December '05
- ✓ Tactics, Techniques, & Procedures Demo complete February '06
- ✓ First Guided Flight complete May '06
- Critical Design Review August '06
- Fuze Vertical Recovery Test October '06
- Tactical Guided Flight Test November '06



PGMM Target Set

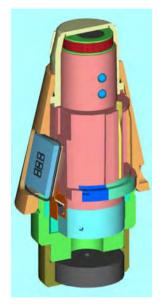








Fuze Commonality



XM784 ETFM

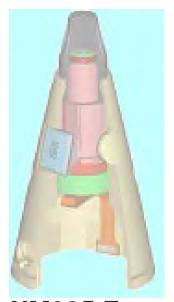
Timed Mortar Fuze for illumination rounds

Fuze Assembly

- ✓ Dual-Processor Safety Architecture
- ✓ Fuze Battery & Activation Mechanism
- ✓ Muzzle-Exit Sensor (2nd Safety Environment)
- ✓ Manual Set Capability (LCD, Switch, Button)
- **✓ FOD Function**
- ✓ S&A Arming
- ✓ Internal Housings
- Inductive Set Capability
- · Main Flight Battery Initiation
- · ISEU Data Communication Interface
- Control Thrust Mechanism Safety Enable

Warhead Initiation Module (WIM)

- ✓ S&A Set-Back Lock Mechanism (1st Safety Environment)
- Det-Delay Electronics
- Explosive Train
- ✓ Indicates Commonality with ETFM

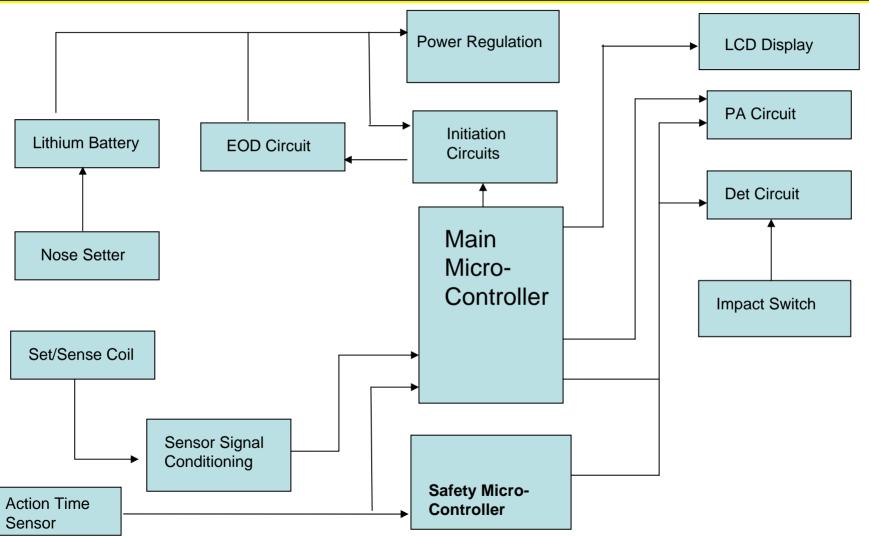




PGMM Fuze Leverages ETFM Design
Designed to Meet MIL-STD-1316E Safety Requirements

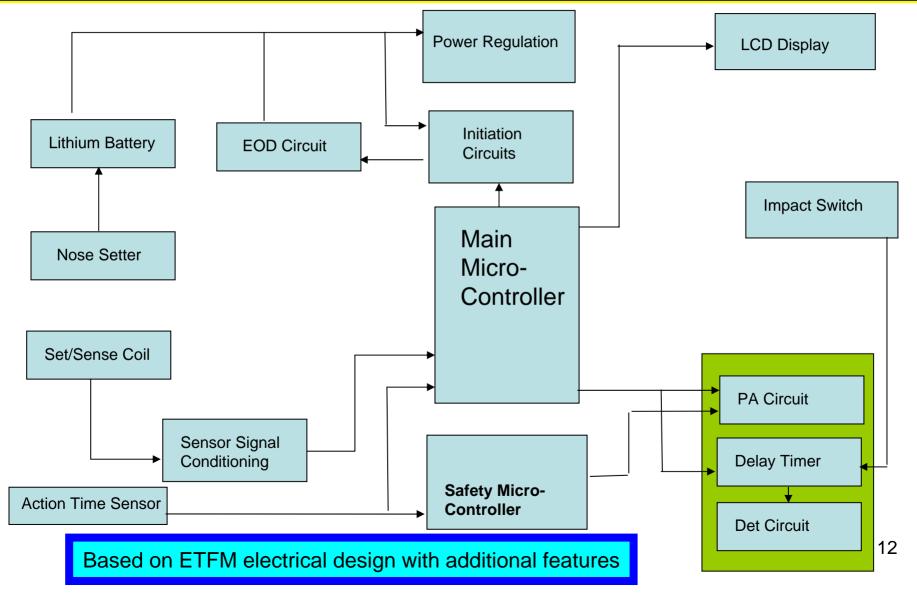


ETFM Electrical Block Diagram



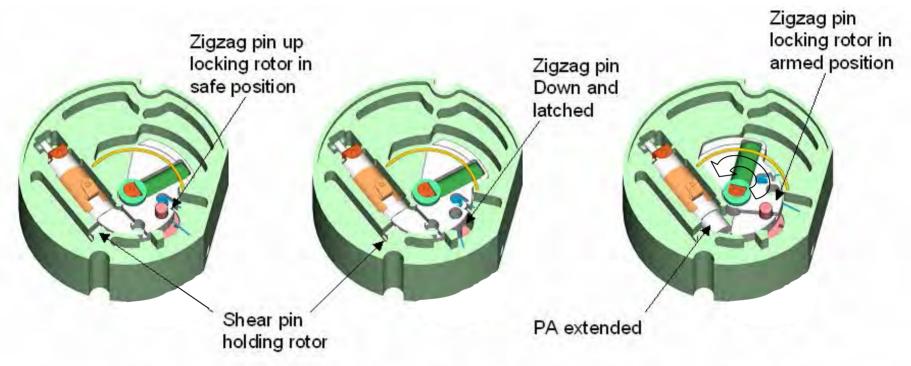


PGMM Fuze & WIM Electrical Block Diagram





PGMM Mechanical S&A



Safe position (as assembled)

1st lock latched (after setback)

Armed (after PA function)

Based on ETFM mechanical S&A design ATK Patent Number 5,693,906



Soldier Feedback

- The PGMM system is in great demand by the soldiers on the ground in Iraq
 - Maneuver Force: "It definitely builds our confidence. I mean, as an Infantry guy, mortars are one of the things you're most scared of. If you can put it within a meter, that's a reasonable window. This thing will be great." TTP Demo, Fort Benning, GA, 17 Feb 06



FO Team FOS and Laser Designator



M1064 Mortar carrier MFCS & PGMM Slug Rounds



Threat Sniper
Position after PGMM
Hit



Maneuver Squad Attacking Village



Summary

- PGMM is a unique munition needed by the soldier in today's complex battlefield.
- Utilizing existing design concepts and parts has greatly reduced design time and cost
- Utilizing common parts will continue to keep the production costs down for both PGMM and ETFM
- This modular concept will allow for continued growth as increments are pursued to increase future capabilities.

PGMM:

Truly a New Application for an Existing Fuze

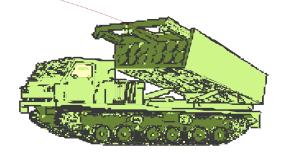




Proximity Sensor for

Guided Unitary Multiple Launch Rocket System

50th Annual NDIA Fuze Conference May 9-11, 2006





Overview

- System Background
- System Requirements
- Design Challenges
- Design
 - ◆ Antenna/Radome
 - **♦** Electronics
 - Signal Processor
 - Transceiver







System Background

- Multiple-Launch Rocket System (MLRS)
 - **♦**Legacy system
 - **EXECUTE** LRIP 1980
 - Ballistic trajectory
 - DPICM payload
 - ♦ GPS/IMU Guidance added 2000
 - ◆DPICM payload with unitary 2002
 - Needed proximity sensor for maximum lethality
 - KDI/EDC turned on in December 2003







System Requirements

- Selectable Height of Burst (HOB): 3m/10m
- 15° to 110° approach angle
 - ◆ Roll-stabilized
- 250m/s to 850m/s approach velocity
- Built-in-Test (BIT)







Design Challenges

- Radome/Antenna
 - **♦** Thermal environment
 - Nose gets EXTREMELY hot
 - ◆ Cover push-through
 - Tube exit presents significant mechanical load
 - ◆Broad angle of attack







Design Challenges

- **■** Electronics
 - **♦** Velocity
 - Exceeds capabilities of existing transceiver/processor chip sets
 - **♦**BIT
 - Not available with legacy ASIC-based signal processors
- Aggressive Schedule
 - ◆ Approximately 13 months to CDR

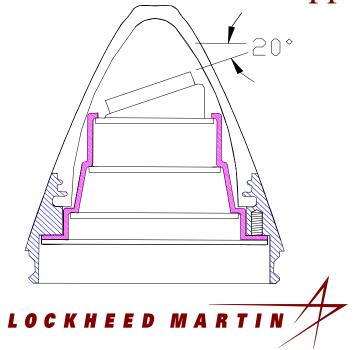






Radome/Antenna

- Proposed concept was simple patch antenna and plastic radome (PEEK)
 - ◆ Antenna would be tilted to provide shallow angle coverage
 - ◆ PEEK has been used in rocket applications







Radome/Antenna

- LM concerned about thermal and mechanical radome environments
 - ◆ High temperature due to velocity
 - ◆ Severe tube-exit mechanical stress
- After contract award, LM analysis shows that PEEK won't with stand environments
 - ◆Suggest that nose must be metal.....!







Radome/Antenna Concepts

- A window on the side of a metal nose would be provided for the antenna
- Various concepts were considered
 - ♦ Waveguide aperture
 - ◆ Patch antenna mounted in/under window
- Analysis tool was needed
 - ◆ KDI acquired a 3D EM analysis tool to quickly evaluate various options

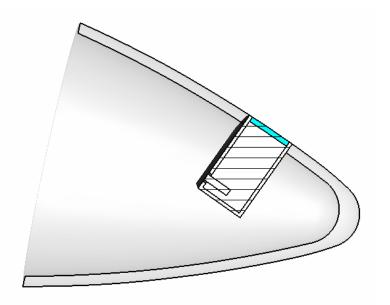


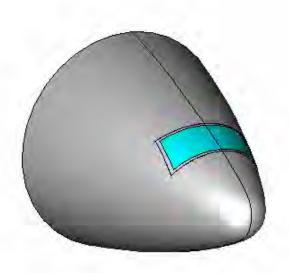




Waveguide Aperture

- Window would form waveguide aperture
 - ◆ Provided good coverage
 - ◆ Not practical to build/assemble

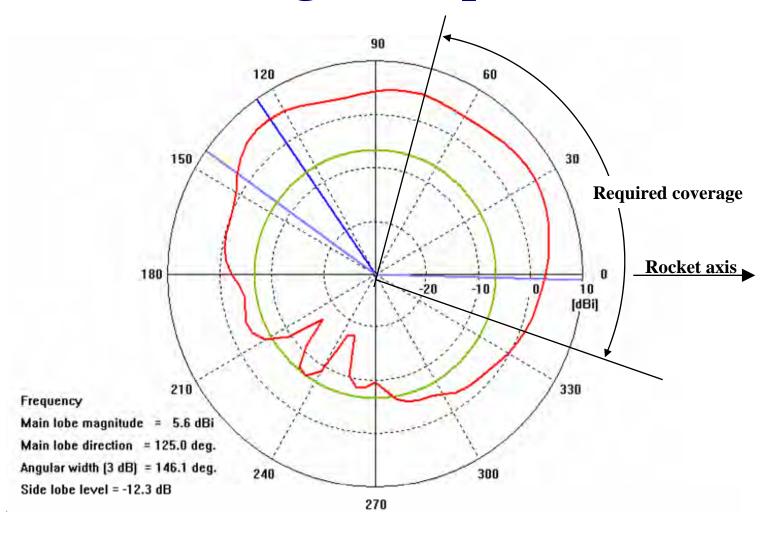








Waveguide Aperture



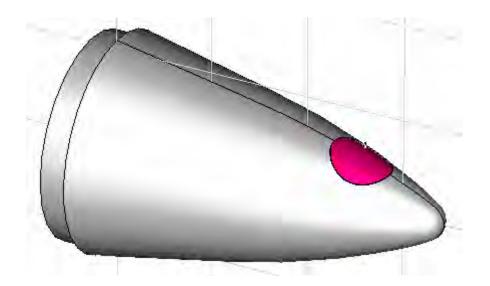






Patch Under Window

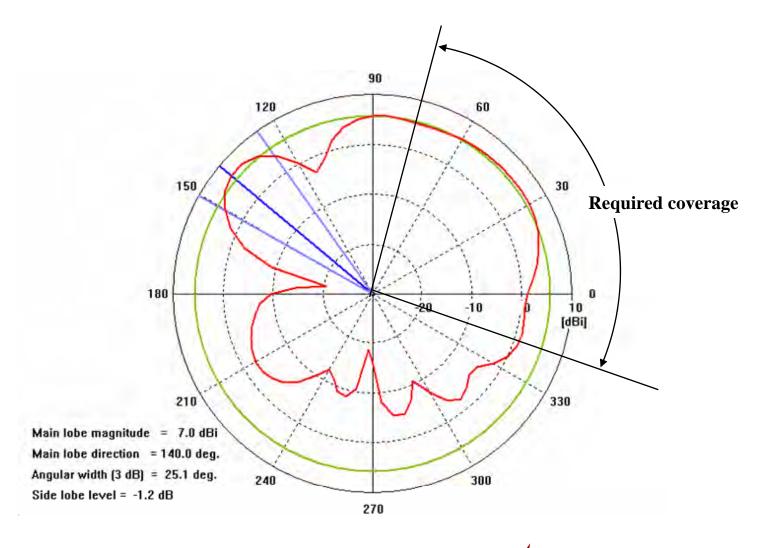
- Simple patch antenna mounted under window
 - ◆ Difficult to mount
 - **♦** Less-than-optimal pattern







Patch Under Window









Ceramic Radome To The Rescue!

- Concurrently with KDI/EDC, LM did extensive thermal and mechanical analysis of nose tip
 - ◆ Identified proprietary ceramic material that could serve as entire radome/nose tip
 - Will withstand thermal and push-through environments
 - ◆ Greatly simplified mounting concerns
 - Back to original concept

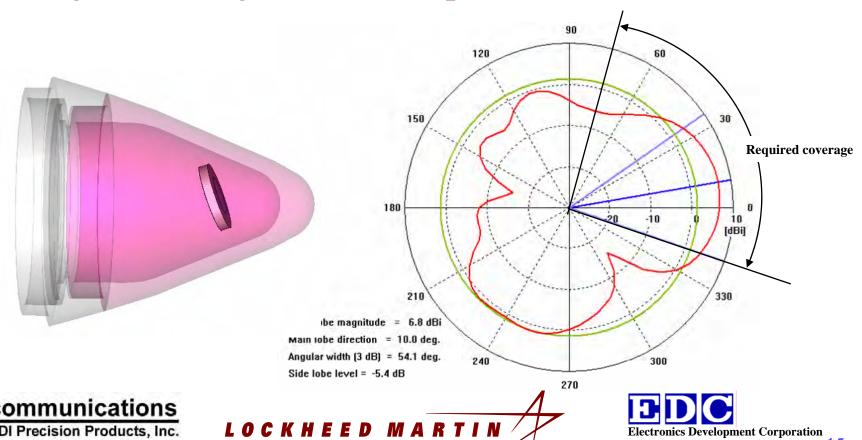






Not So Fast...

- High dielectric constant had significant influence on pattern (and impedance)
 - ◆ Original 20 degree tilt concept didn't work too well



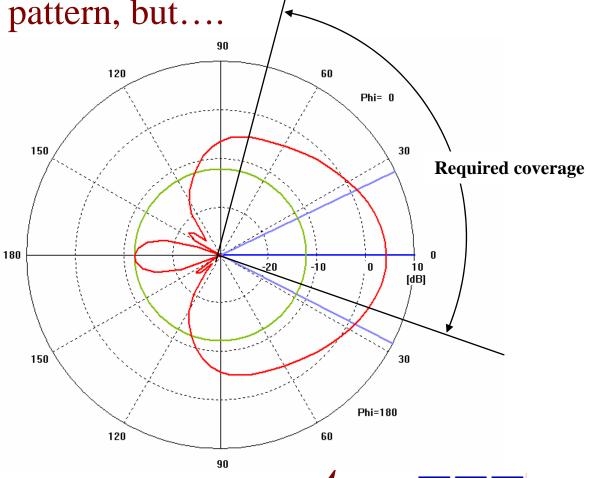




Un-tilted Antenna

■ Analyzed un-tilted antenna

♦ Very narrow pattern, but....





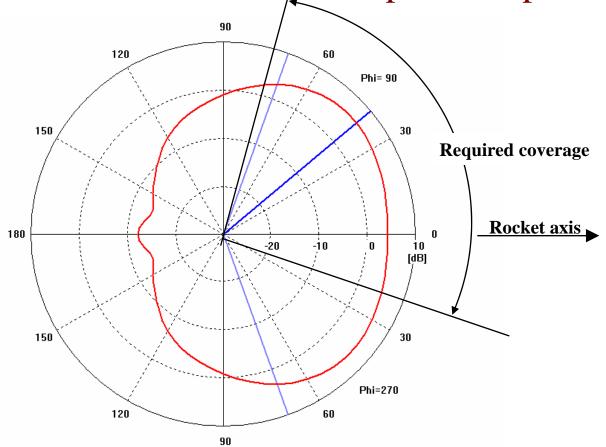




Un-tilted Antenna

■ Horizontal cut

◆ Antenna rotated so that this corresponds to pitch plane



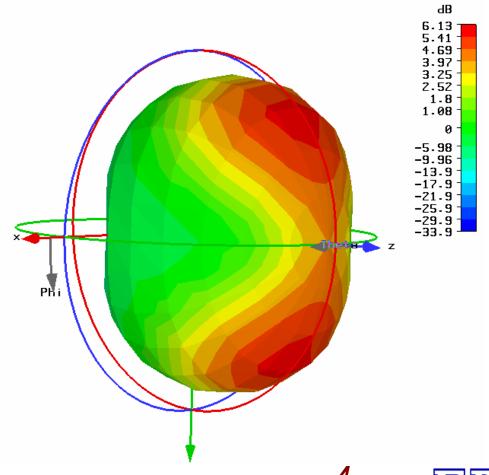






Final Antenna Configuration

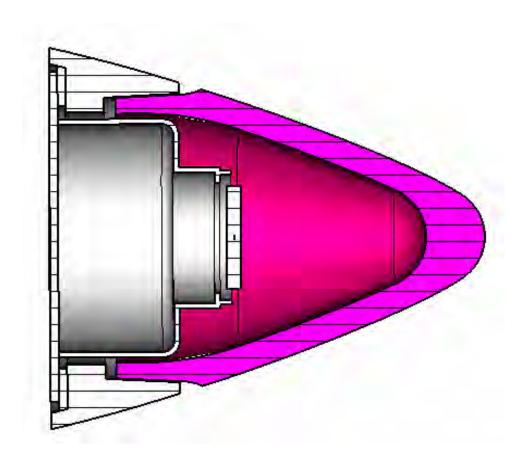
■ Show figure of 3D pattern







Final Antenna Configuration



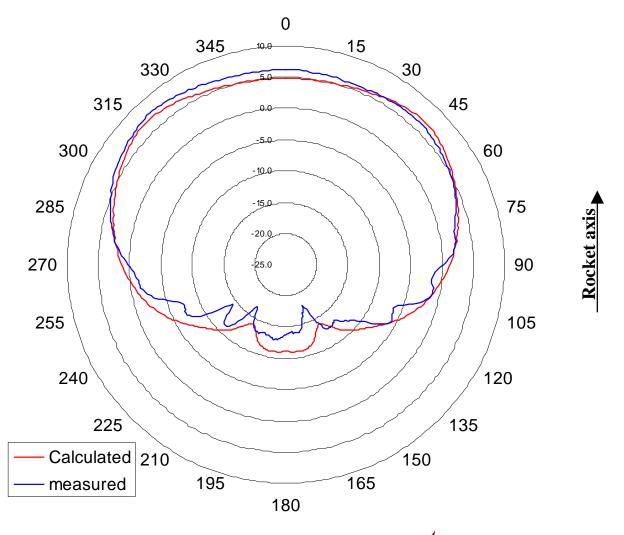






Antenna Performance

Pitch Plane, Measured vs Calculated









Electronics Design Signal Processor

- Requirements precluded use of existing signal processor
 - ◆ High velocities result in Doppler frequencies outside the passband of existing mortar and artillery processing systems
 - ◆Built-in-Test (BIT) not possible with existing processors
 - ◆ Aggressive schedule made new ASIC impossible







Electronics Design Signal Processor

- KDI/EDC leveraged previous IRAD work to design completely new signal processing system
 - ◆ All parameters are re-configurable
 - ◆ Reports BIT status to ESAF, which reports to Mission Computer
 - ◆ All components are commercially available
 - **☞ No custom IC's!**







Electronics Design Transceiver

- Antenna/Radome design yielded good results, but only at a frequency significantly different than those used on legacy mortar and artillery systems
 - ◆ Could not use existing transceivers
 - ◆ Aggressive schedule made new MMIC impossible
 - ◆ New transceiver designed with commercially available components
 - **☞ No custom IC's!**







Electronics Assembly







Summary

- Difficult radome/antenna problem solved through TEAMWORK
 - ◆ Concurrent electromagnetic, thermal, and mechanical analysis
- Electronics contains NO custom components
 - ◆ Rapid development
 - ◆ Versatile design
- First shot success (see next slide)!

















KDI Precision Products, Inc. 3975 McMann Road Cincinnati, Ohio 45245-2395

Affordable Weapon System







ESAF & HOB Design

John Hubert & Brian Miracle

NDIA 50th Annual Fuze Conference

May 9-11, 2006

Proprietary www.l-3com.com

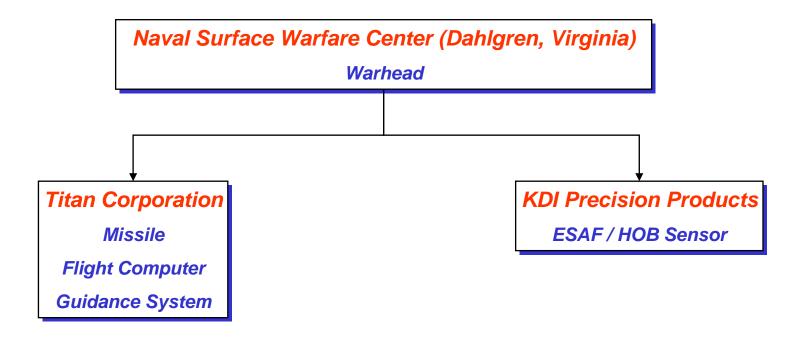






Affordable Weapon System (AWS) Overview

Program Organization







Affordable Weapon System (AWS) Overview

Features

Dimensions:

• Length: 155 - in

• Diameter: 13.5 - in

• Wingspan: 146.4 - in

Payload 200 lb

Range (T/O): 600 / 840 miles

Speed

Stall/Max 128/220 knots

Cruise 150 knots

• Endurance (T/O): 4 / 6 hours

Accuracy (CEP): ~10 meter

Launched from surface ship











AWS ESAF/HOB Major Design Goals

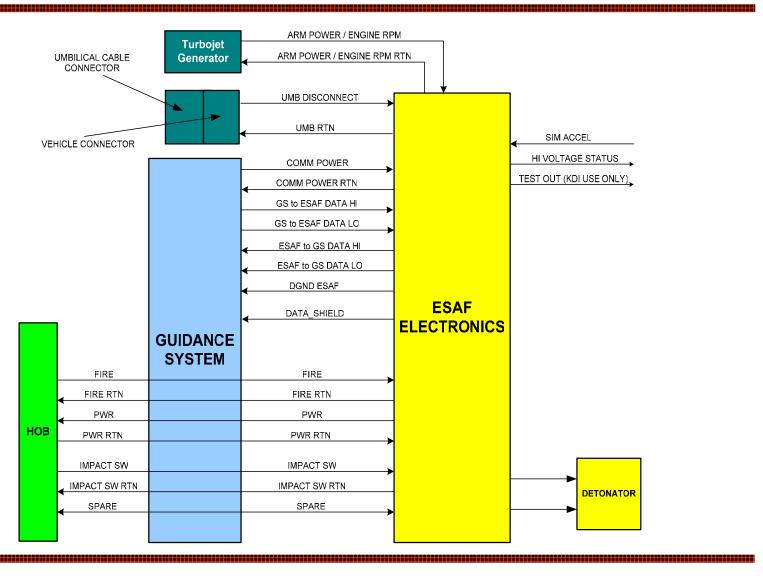
- ESAF compliant with MIL-STD 1316
- ESAF/HOB to utilize existing technologies to rapidly prototype
- ESAF to initiate with HOB command, HOB impact with target, or ESAF internal impact (backup)
- HOB to initiate warhead at 6 feet above surface or upon impact (primary firing modes)







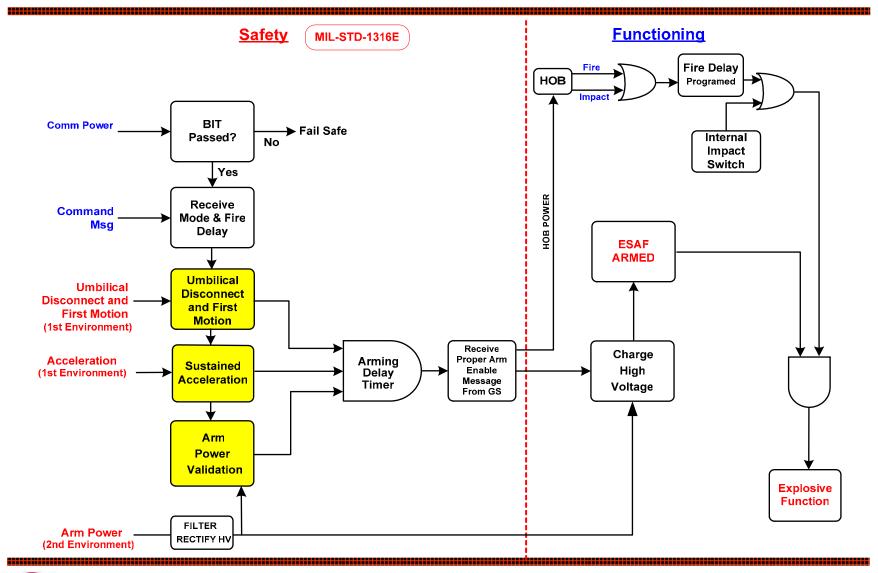
AWS System Block Diagram







AWS ESAF Functional Block Diagram









AWS ESAF







AWS ESAF Electronics Assembly

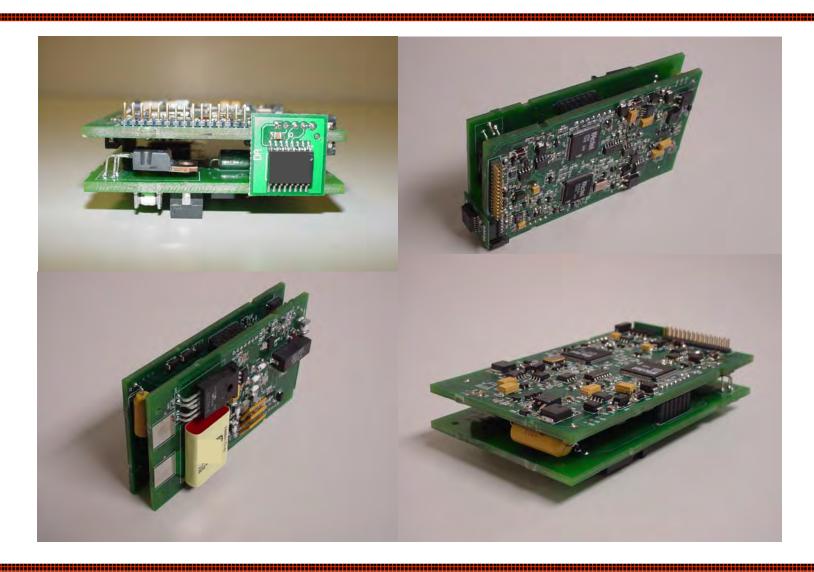








AWS ESAF Circuit Card Assembly









AWS Challenges

- Program
 - Low development budgets
 - Accelerated schedule
- Technical
 - Limited technical specifications at program onset
 - Adapt existing technology to meet program requirements







AWS Program Challenges

- Low development and unit budgets / Accelerated schedule
 - Utilize existing "Off The Shelf" technology
 - Package Form Factor
 - PWB Form Factor / Layout
 - Circuit Architecture
 - Common Parts
 - Risk
 - Low
 - Modifications to existing technology







AWS ESAF/HOB Design Challenges

ESAF

- Wide arming voltage input range over temperature vs. design target of "off the shelf" design
- Addition of accelerometer to "off the shelf" design
- Limited environmental safety signatures (ESAF)
 - Umbilical
 - Acceleration (minimal)
 - Arming Power

HOB

- Incorporate impact switch into existing design
- Input voltage range
- Packaging
 - Radome shape
 - Interface cabling







AWS ESAF Design Challenge

- Wider and lower arming voltage input range
 - Utilize existing high voltage generation circuit
 - Circuit originally designed for a much higher/regulated voltage over temperature versus the lower and wider voltage range for the AWS.
 - AWS arming power is derived from a turbine generated AC voltage and is rectified to a DC level.
 - Component changes to accommodate wider and lower arming power voltage
 - Dynamic clock optimized to achieve HV regulation within specified time frame





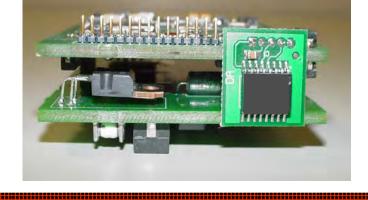




AWS ESAF Design Challenge

- Accelerometer required
 - Low acceleration levels
 - Limits available COTS accelerometers
 - Ship motion may be a significant factor
 - Launch angle offset must be accounted for
 - Packaging/Orientation
 - Addition of small circuit board
 - Limited choice of available devices featuring the acceleration level and

orientation required

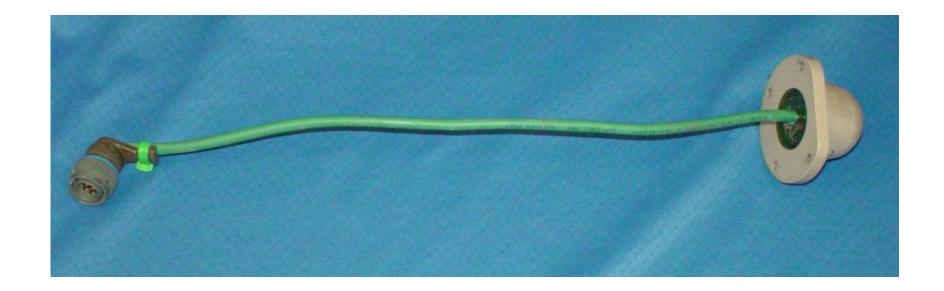








AWS Height of Burst Sensor







AWS Height of Burst Sensor

- Based on DDR proximity detection technology used in the highly successful M734A1 Multi-Option Fuze for Mortars (Over 750,000 units delivered)
- Uses a highly integrated single-chip signal processor
- KDI-designed low-cost transceiver
- Extremely robust patch antenna with integrated transceiver circuitry









AWS HOB Design Challenges

- Incorporate impact switch into design
- Modify mechanical package to interface with AWS nose section
- PWB and cable modification to provide required signals
- Cabling and connector to meet space constraints
- Modification of design to meet lower input voltage requirement









AWS HOB Design Challenges

- Impact switch required
 - Picked existing normally closed impact switch used on other programs.
 - Mounted between power and processor PWBs
- Modify mechanical package to interface with AWS nose section
 - Modified existing Ogive radome to current design









AWS HOB Design Challenges

- PWB and Cable Modification to Provide Required Signals
 - Modified power PWB to provide additional signals, including interface to impact switch
 - Selected off the shelf cable to incorporate additional signals
- Cabling and Connector to Meet Space Constraints
 - HOB cable interfaces to AWS Using MS27473 Plug with 90 degree backshell that meets limited space requirements between missile wall and socket.









AWS HOB Design Challenge

- Modification of Design to Meet Lower Input Voltage Requirement
 - Lowered series resistance value on power board
 - Meets input voltage range of 8 ± 1VDC across temperature range of -40 to +70 °C.







AWS HOB Design Test Results

- Current design meets height of burst requirement of 6 ± 3 feet at reflection coefficients ranging from 0.2 to 0.8 and temperatures ranging from -40°C to +70°C.
- Functions acceptably after exposure to AWS in-flight environments.





AWS HOB Design Test Results









AWS ESAF/HOB Program Status

ESAF

- Breadboard unit delivered for system integration
- First design iteration successfully tested for explosive output after exposure to AWS in-flight environments
- Delivered Inert and Live prototype units for test purposes
- Second design iteration started
 - Construction Of IM and Test units started

HOB

- Successful height of burst shot with flash charge
- Delivered prototype units for testing purposes







Conclusion

- KDI successfully provided a timely and cost effective solution for the AWS program by:
 - Adapting a common and proven 3" architecture/form factor
 - Adapting a proven, high volume, HOB design
 - Closely working with the customer
 - Regularly scheduled meetings
 - Written status reports by program management
 - State of the art manufacturing



50th Annual Fuze Conference



Wednesday, May 10

- ☐ Session III-A (Chair: Mr. Eric Roach)
 - 1:00 PGMM, New Application for an Existing Fuze
 - 1:20 Proximity Sensor for the GMLRS
 - 1:40 <u>Multifunction Programmable Fuze 260MF</u>
 - 2:00 Portable Excalibur Fire Control System
 - 2:20 <u>Enhanced Portable Inductive Artillery Fuze Setter</u>
 - 2:40 Air Burst Munitions for Cannon Caliber Applications
 - 3:00 BREAK
 - 3:20 Evolution of DSU-33 C/B Proximity Sensor
 - 3:40 FY06 Foreign Comparative Test of PIMPF
 - 4:00 Dev & Qual of programmable Fuze for MK285
 - 4:20 A New Fuze for an Electromagnetic Gun
 - 4:40 Intro of MOFA DM84 on 120mm Rifled Mortar
 - 5:00 TBD

50th Annual Fuze Conference



Thursday, May 11

- Session IV-A (Chair: Dave Lawson)
 - 8:00 Enhancing Dispenser System Function...
 - 8:20 Challenges Assoc. w/Development of Afford...
 - 8:40 FMU-139C/B Electronic Bomb Fuze Design
 - 9:00 Shipboard Submunition Fuze Safety & Relia...
 - 9:20 TBD
 - 9:40 Thermal Battery Development-Reduced Varia...
 - 10:00 BREAK
 - 10:20 <u>Guidance Integrated Fuze (GIF)</u>
 - 10:40 GIF: Dev & Test of a Roll Control Joint
 - 11:00 Perf. Testing of Lead-Free Stab Detonators
 - 11:20 TNO Research on EFIs in Relation to IM
 - 11:40 LUNCH



Shipboard Submunition Fuze Safety and Reliability Improvement

John Kunstmann NSWC IH Code E314F Kunstmannjf@ih.navy.mil (301) 744-1190



Shipboard Submunition Fuze Safety and Reliability Enhancement

- Sponsored by ONR 353
- Outgrowth of FY04 effort:

Assessment of Technologies for USMC HIMARS Submunition Fuze Design

 Evolved Into Broad Based Multi-Year Technology Effort Looking at all Applicable Munitions



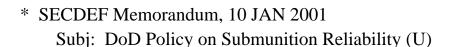
Shipboard Submunition Fuze Safety and Reliability Enhancement

- ISSUE A number of existing, widely used submunitions do not currently meet either the Navy WSESRB established shipboard safety requirement or the SECDEF policy for Submunition Reliability.
- A low-cost solution is needed to both allow submunitions to be safe enough to be used in future shipboard carried weapons systems and reliable enough to be employed in the field.



DRIVING FACTORS

- **OSD** Policy: field future submunitions with a 99% or higher functioning rate*
- WSESRB Position: Shipboard Submunitions must have a probability of less then one in a million for either of the following cases:
 - Arming when inadvertently dispensed from the munition.
 - Inadvertently being dispensed from the munition.**



** NAVSEASYSCOM Letter 8020 Ser N314-H-22-001/373, 28 APR 04

Subj: WEAPON SYSTEM EXPLOSIVES SAFETY REVIEW BOARD EXECUTIVE SESSION MEETING ON SAFETY REQUIREMENTS FOR WEAPONS CONTAINING SUBMUNITIONS





- Current Army efforts focus on adding Self-Destruct Feature to existing fuze structure to meet 99% functional reliability.
- This approach "places the ship at increased risk since the submunitions will now be designed to reliably function regardless of how they are expelled from the carrier munition, intentionally or inadvertently."*

*NAVSEASYSCOM Letter 8020 Ser N314-H-22-001/373, 28 APR 04

Subj: WEAPON SYSTEM EXPLOSIVES SAFETY REVIEW BOARD EXECUTIVE SESSION MEETING ON SAFETY REQUIREMENTS FOR WEAPONS CONTAINING SUBMUNITIONS



Safety is related to the ability to prevent undesired hazardous events. Safety is typically quantified as rate of Failure:

e.g. Failure of 1 in
$$1 \times 10^6 = 1/10^6 = 1 \times 10^{-6}$$

Safety can also be expressed as Safety-Related Reliability:

e.g.
$$R_S = 1 - F = (1 - 1 \times 10^{-6}) = .9999999$$

Reliability commonly refers to the ability to perform the desired function at the desired time, i.e. Functional Reliability. Typically quantified as rate of Function:

e.g. Function of 99 out of 100 = 99/100 = .99



Safety and Reliability can be altered by:

- •Fault Avoidance Keep Problems from Occurring
 - Component Quality
- •Fault Tolerance Some Problems OK
 - Component Redundancy



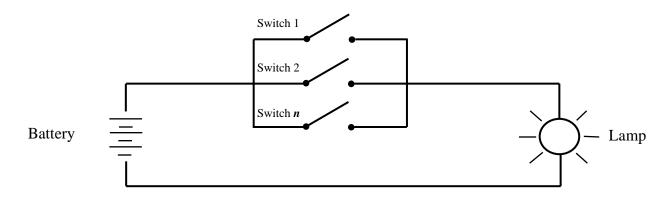
Fault Avoidance:

High Quality Components = Fewer Problems

- •Quality can be hard to quantify (what makes a part "better" in a given situation)
- •Higher quality typically means higher cost
- •Very high quality can be hard to achieve and demonstrate



Reliability Related Fault Tolerance: Parallel Components



$$P_p = 1 - \prod_{i=1}^{n} (1 - P_i)$$

where,

 P_p = the probability of event in the parallel system

 P_i = the probability of the event in the subsystem

n =the number of subsystems

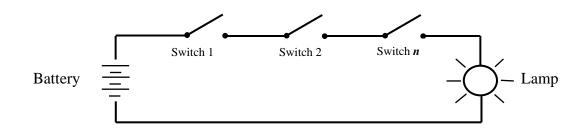
Example:if probability of an event for a component is 1 in 10 (10%) the system probability for 3 of these components in parallel would be:

$$P_p = 1-(1-0.1)(1-0.1)(1-0.1) = 0.271 \text{ or } 27.1\%$$

Parallel Systems Increase Event Probability



Safety Related Fault Tolerance: Series Components



$$\mathbf{P}_{\mathrm{s}} = \prod_{\mathrm{i}=1}^{\mathrm{n}} \mathbf{P}_{\mathrm{i}}$$

where,

 P_s = the probability of event in the series system

 P_i = the probability of the event in the subsystem

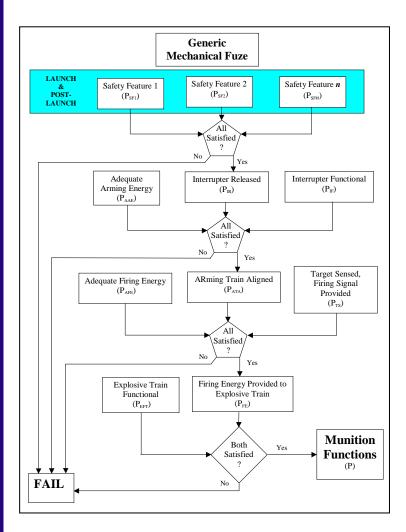
n =the number of subsystems

Example: if probability of an event for a component is 1 in 10 (10%) the system probability for 3 of these components in series would be:

$$P_s = (0.1)(0.1)(0.1) = 0.001$$
 or 0.1%



Generic Fuze Functional Reliability



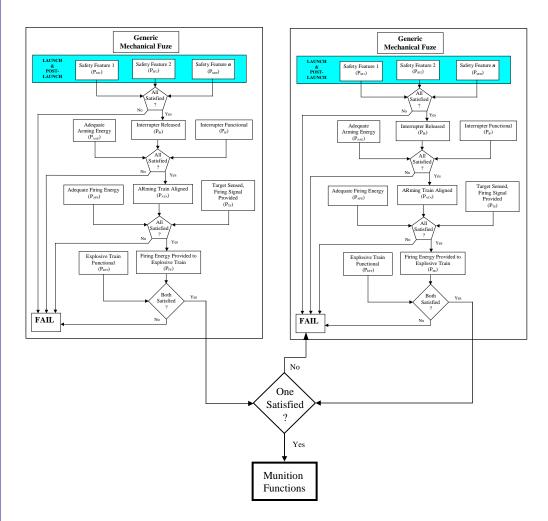
With single fuze

$$\begin{split} P &= (P_{fe})(P_{eft}) \\ &= ((P_{ata})(P_{afe})(P_{ts}))(P_{eft}) \\ &= (((P_{ir})(P_{aae})(P_{if}))(P_{afe})(P_{ts}))(P_{eft}) \\ &= ((((P_{sf1})(P_{sf2})(P_{sfn}))(P_{aae})(P_{if}))(P_{afe})(P_{ts}))(P_{eft}) \end{split}$$

Required
Submunition
Reliability ≥ 99%



Generic Fuze Functional Reliability



With 2 parallel fuzes

$$P = 1 - (1 - P_{FA1})(1 - P_{FA2})$$

P = Probability of Munition Function $P_{FA1} = Probability of Fuze 1 Function$ $P_{FA2} = Probability of Fuze 2 Function$

Assuming that the fuzes have equal probability of arming $(P_{FA1} = P_{FA2})$, and $P \ge 99\%$ to meet the OSD requirement, then the equation reduces to:

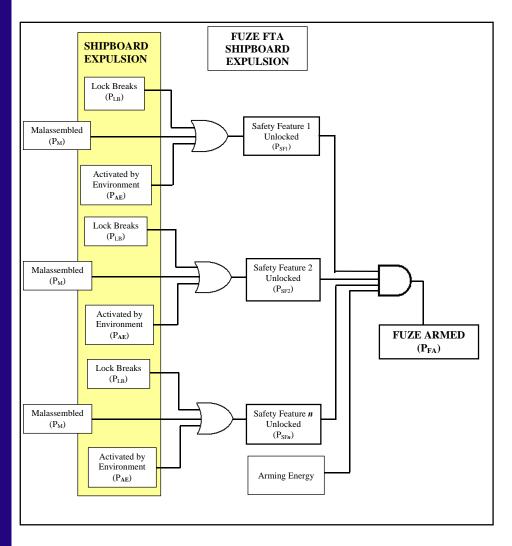
$$\begin{split} P &= 1 \cdot (1 \cdot P_{FA1})(1 \cdot P_{FA1}) \\ P &= 1 \cdot (1 \cdot P_{FA1})^2 \\ P &= 1 \cdot (1 \cdot 2P_{FA1} + (P_{FA1})^2) \\ P &= 2P_{FA1} \cdot (P_{FA1})^2 \\ 0 &= 0.99 - 2P_{FA1} + (P_{FA1})^2 \end{split}$$

Solving the quadratic yields

$$P_{FA1} \ge 90\%$$



Generic Fuze Safety



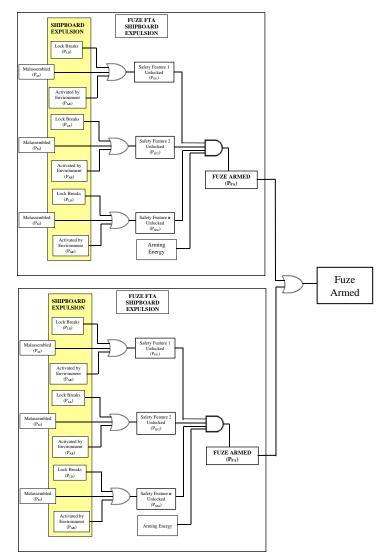
With single fuze

$$P_{FA} = (P_{SF1})(P_{SF2})(P_{SFn})$$

 $P_{FA} \le 1 \times 10^{-6}$



Generic Fuze Safety



With 2 parallel fuzes

$$P = 1 - (1 - P_{FA1})(1 - P_{FA2})$$

P = Probability of Either Fuze Arming

 P_{FA1} = Probability of Fuze 1 Arming

 P_{FA2} = Probability of Fuze 2 Arming

Assuming that the fuzes have equal probability of arming

 $(P_{FA1} = P_{FA2})$, and $P_{FA} \le 1 \times 10^{-6}$ to meet the WSESRB requirement, then the equation reduces to:

$$P_{FA} = 1 - (1 - P_{FA1})(1 - P_{FA1})$$

$$P_{FA} = 1 - (1 - P_{FA1})^2$$

$$P_{FA} = 1 - 1 + 2P_{FA1} - (P_{FA1})^2$$

$$0 = P_{FA} - 2P_{FA1} + (P_{FA1})^2$$

$$0 = 1 \times 10^{-6} - 2P_{\text{FA}1} + (P_{\text{FA}1})^2$$

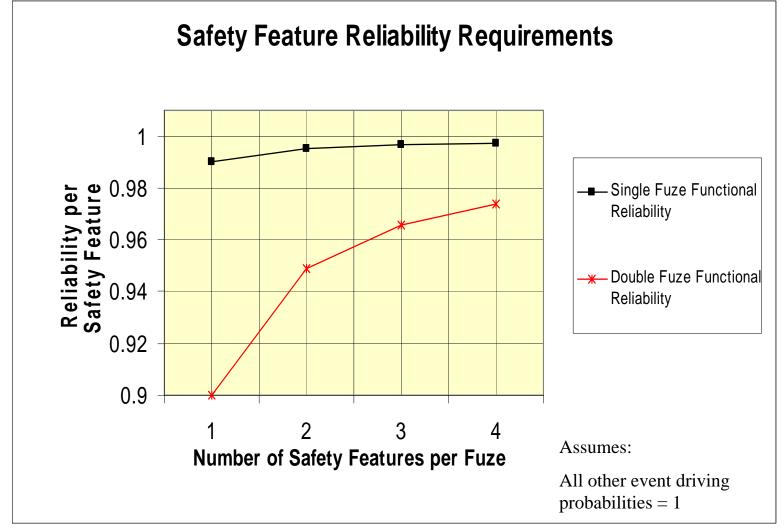
$$P_{FA1} = 5 \times 10^{-7}$$

Or less then 1 in 2 million

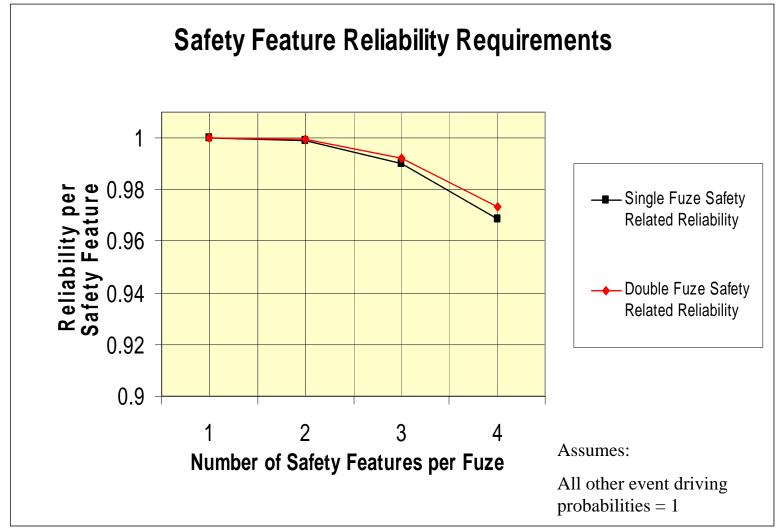


Number of		Functional Reliability Requirements per Individual Safety Feature			Safety-Related Reliability Requirements per Individual Safety Feature	
Safety Features		Single Fuze	Dual Fuze		Single Fuze	Dual Fuze
1		0.99	0.9		0.999999	0.9999995
2		0.994987437	0.9486833		0.999	0.9992929
3		0.996655493	0.9654894		0.99	0.992063
4		0.99749057	0.9740037		0.968377223	0.9734085
5		0.997991952	0.9791484		0.936904266	0.945072

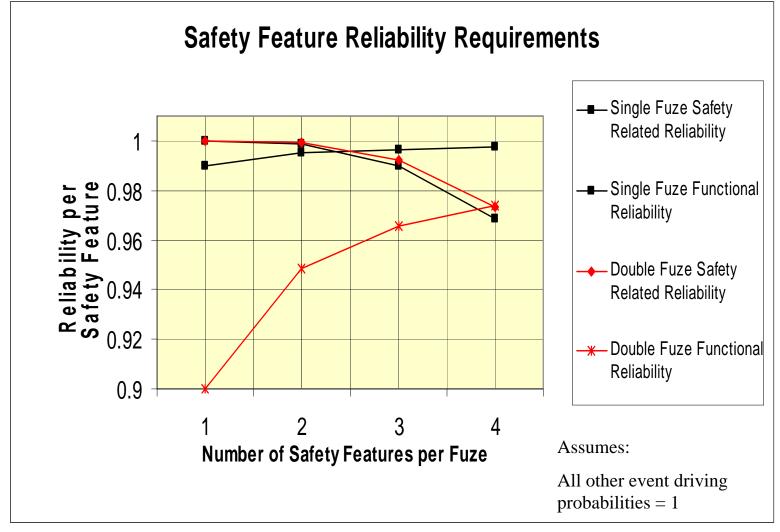












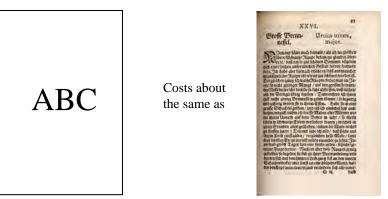


Using two parallel fuzes each with three safety features in series allows meeting of the reliability and safety requirements using components having more easily obtainable reliability.



MEMS as a Means to Achieve Dual Fuzing

- Readily manufactured at numerous commercial facilities.
- At the chip level there is no assembly required regardless of the number of features.
- Much like photocopying, increasing MEMS features does not significantly affect cost.







FMU-139C/B Electronic Bomb Fuze Design Update

Thursday, May 11, 2006

David Liberatore ATK Tactical Systems (304)726-7587 50th Annual NDIA Fuze Conference Norfolk, VA

Distribution Statement A approved for public release; distribution is unlimited.





An advanced weapon and space systems company

FMU-139 Description FMU-139 Background **ATK FMU-139B/B History** FMU-139C/B Design

- Requirements
- Design Approach
- Results
- **Status**







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General-Purpose, Electro-Mechanical Bomb Fuze

- Joint-service fuze (NAVAIR PMA-201 is lead service)
- Used with M117 and MK80 GP warheads, incl. JDAM and Paveway
- Out-of-line, rotor-based safing and arming

Versatile, Multi-Mode Performance

- Selectable arm times: 2 to 20 seconds
- Impact, proximity, or delay detonation settings
- ngs

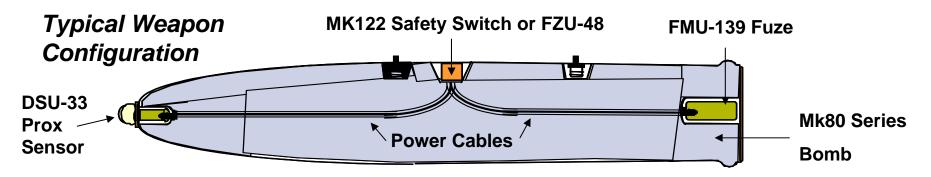
 CS operav burst (LISM)
- Powered by FZU-48 Initiator (USAF) or FFCS energy burst (USN)
- Offers limited cockpit programmability in FFCS mode
- Capable of high or low drag delivery; auto-detects drag conditions

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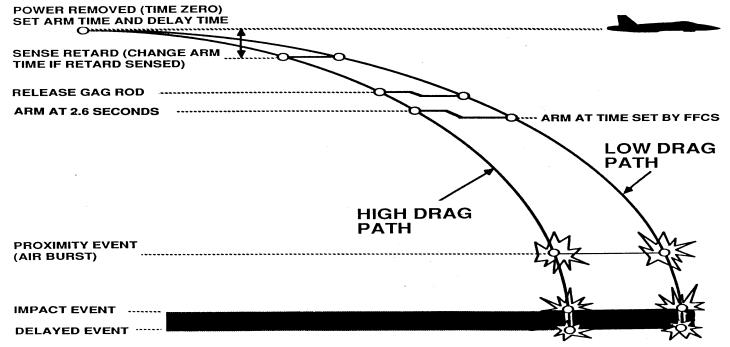
FMU-139 Description (cont'd)



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NAVY MODE DELIVERY PROFILE



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FMU-139 Background



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FMU-139/B development completed in 1980's by USN/Motorola

- One of the first fuzes to utilize a microprocessor
- Over 800,000 FMU-139A/B fuzes produced through 1995 by Motorola USN developed FMU-139B/B in 2000 and upgraded its inventory:
 - Improved IM: Replaced CH-6 Booster with PBXN-7
- Improved ESD Protection: Added Transient Voltage Suppression

ATK acquired Motorola fuzing design and production assets in 1998



FMU-139: Supporting Freedom for More Than 20 Years!

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ATK FMU-139B/B History



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An international market for FMU-139 existed but:

- FMU-139A/B no longer producible component obsolescence
- USN issued an FMU-139B/B performance specification

ATK Approach - retain proven design but address obsolescence:

- Replaced COP4 microprocessor with COP8; rewrote software
- Replaced timing crystal, firing circuit thyristors, encapsulant
- Also incorporated USN FMU-139B/B IM and ESD improvements



ATK B/B incorporated Transient Voltage Suppression (TVS) components into main circuit board ————

USN FMU-139B/B

ATK FMU-139B/B

ATK FMU-139B/B History (cont'd)



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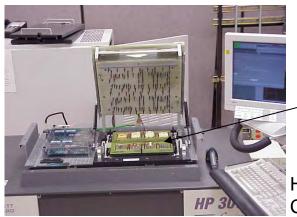
Navy design oversight and approval was required to assure safety, reliability, and interoperability:

- Utilized a Commercial Services Agreement (CSA) with USN
- Design certification and safety approvals granted 2001 & 2002

Passed software FQT and First Article Testing in 2001

Over 9,000 fuzes were delivered to several allied nations 2002 – 2004

USN oversight continued during international production via CSA



Performance assured by electronic testing at both board level and fuze level

HP3070 CCA Tester EDT 4 Fuze Tester



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FMU-139C/B Requirements



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New mission scenarios required longer time of operation in pulsed power (Navy FFCS) mode:

- Increased mission life from 1 to 4 minutes
- Increased inrush current from 80 to 135 mA

Improved safety required resolution of two legacy concerns:

- Ensure microprocessor reset at power-up to preclude early enable (firing of piston actuator)
- Prevent out-of-sequence firing of Bellows Motor (at or before PA fire)





⁸

FMU-139C/B Design Approach



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Continued spiral improvement to the proven FMU-139 family

Hardware Highlights:

- Increase energy storage capacitance by 125%
- Use precision reference diodes (stabistors) for superior control
- Re-layout Printed Wiring Board
- Revise Gag Flex to short Bellows until cut by Gag Rod at enable
- Minimize changes 7 new parts, 6 deletes, 16 value changes = 29 total

Software Highlights:

- Improve energy management
- Split initial firing capacitor charge into 2 phases
- Reduce firing capacitor refresh rate

Risk Mitigation Highlights:

- Perform Design Verification Testing (DVT) early
- Perform 20-unit Confidence Build after CDR



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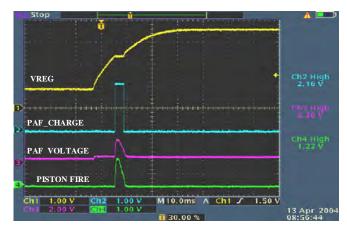
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Lifetime Requirement Met with Robust Margin!

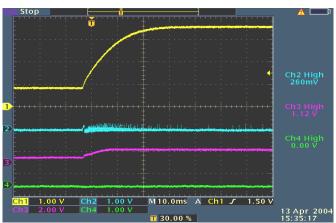
- Requirement = 240 sec, minimum
- Demonstrated = 330 sec (ambient), 300 sec (cold), 290 sec (hot)
- Max current draw of 135 mA met = 128 mA max observed

Safety Improved!

- Revised Gag Flex shorts Bellows until enable completed
- Reset Circuit improved to prevent early PA fire at power-up



Before – Note Enable at Power Up



After Reset Circuit Improvements

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FMU-139C/B Status



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Build of First Article fuzes has been completed

First Article Testing currently in progress and will complete in June

• FAT must demonstrate 95% reliability at 90% confidence

Required safety presentations have been made to the Navy Technical Review Panels – Fuze Initiation (FISTRP) and System Software (SSSTRP)

Initial Production delivery planned for September



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Proven, legacy design fully understood



New customer requirements fully understood



Changes kept to a minimum



Extensive testing performed



RESULT: FMU-139C/B is on track!

The FMU-139 Fuze will continue to support freedom for years to come.....

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ANY QUESTIONS??

Contact Information:

Dave Liberatore

ATK Tactical Systems

(304)726-7587

dave.liberatore@atk.com



THANK YOU!

¹³ Distribution Statement A approved for public release; distribution is unlimited.



Performance Testing of Lead-Free Stab Detonators



05/11/2006 NDIA Fuze Conference

Author: Neha Mehta RDECOM Chemical Engineer

Co-Authors:

Gartung Cheng - RDECOM
Emily Cordaro – RDECOM
Neelam Naik - RDECOM
Bobby Lateer - RDECOM
Carl Hu – RDECOM
Daniel Stec – SAIC
Kathy Yang - SAIC







- Introduction
- Objective
- Initiating Charge Replacements
- Transfer Charge Replacements
- New Detonator Design
- Benefits
- Test Results and Comparison
- Questions







- Current issues with primary explosives in detonators:
 - No US Lead Azide production
 - Environmentally hazardous
- Initiated a program to develop a lead-free stab detonator

Stab Mixture

Lead Azide

Output Charge **Primary**

Lead Azide

Output Charge





Program Objectives

Replace NOL-130 (initiating charge) and Lead Azide (transfer charge) with green materials.







- Replacing the initiating charge will eliminate some of the lead
 - Must initiate with same stimulus
 - Must be powerful enough to cause transfer charge to detonate
- Lead-free stab mixture
 - Based on NOL-130
 - Lead-based components replaced





Initiator Mix Composition

NOL-130	NOL-130G		
Lead Azide	Cyanusic Triazida		
Lead Styphnate	Cyanuric Triazide		
Tetracene	Tetracene		
Barium Nitrate	Barium Nitrate		
Antimony Trisulfide	Antimony Trisulfide		





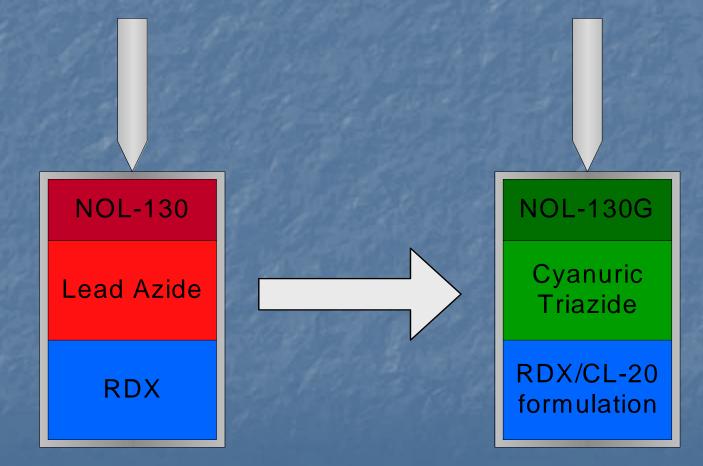


- Replacing the transfer charge will eliminate rest of the lead
 - Must be sensitive enough for detonation transfer
 - Must be powerful enough to cause high order reaction of output charge
- Cyanuric Triazide



Lead-Free Stab Detonator









Benefits

- Lead-Free Material
- Give US manufacturing capability
- Eliminates single point failure source in fuze/detonator supply chain
- Utilizes present technology for preparation and production
- Simple production process, with low waste, non-toxic





Sensitivity Tests

- Ball Drop Impact
 - LA: 7-11"
 - NOL-130: 14"
- Electrostatic
 - LA: No Go at 0.0012JGO at 0.0016J

- Ball Drop Impact
 - Cyanuric Triazide: 10"
 - NOL-130G: 9-14"
- Electrostatic
 - Cyanuric Triazide (as formed):
 - No Go at 0.031 J (0/20)
 - Recrystallized Cyanuric Triazide:
 - No Go at 0.0012 J (0/20)





Sensitivity Tests

- Small Bam Friction
 - LA: No Go at 10-20gGO at 30g
- Small Bam Friction
 - Cyanuric Triazide (as formed):No Go at 10g (0/10)Go at 20g
 - Recrystallized Cyanuric Triazide:

Go at the minimum load - 10g





Detonator Ball Drop Test Setup



M55 Detonator Holder





M55 Detonator – Ball Drop Test



#	NOL- 130 (mg)	NOL- 130G (mg)	Lead Azide (mg)	Triazide (mg)	RDX (mg)	EDF (mg)	Comments
1	15			29			GO
2	15			37			GO
3	15			20	19		GO
4	15			20		19	GO
5		15	51		12		GO
6		15		20	17		GO
7		15		20		17	GO





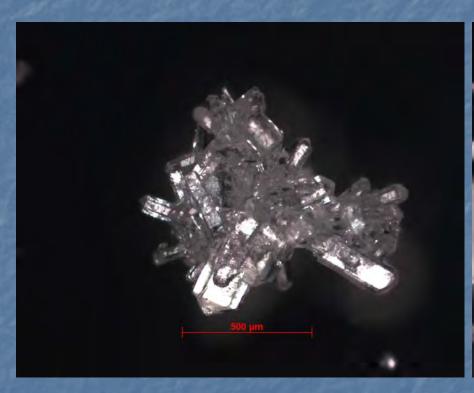


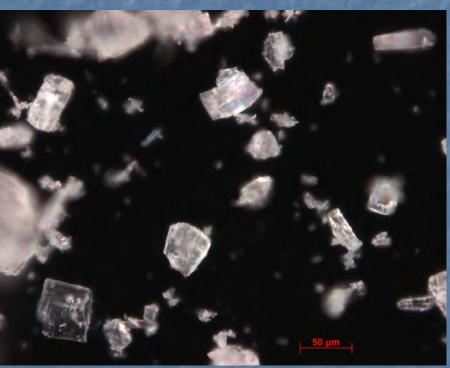












As Formed

Recrystallized





Conclusions

- Developed new stab composition, NOL-130G.
- Replaced Lead Azide with Triazide.
- Investigated the replacement of the output charge with a CL-20 formulation.
- Approved to file a Patent for NOL-130G and Lead-Free Stab Detonator.





Future Work

- Optimize particle size of cyanuric triazide.
- Optimize loading of the transfer and output charges.
- Qualify Cyanuric Triazide and NOL-130G.



Contents

- TNO Organisation
- Exploding Foil Initiator Research
- Research on Explosives
- Conclusion



TNO has organised its business in five core areas



TNO Quality of Life



TNO Defence, Security and Safety



TNO Science and Industry



TNO Environment and Geosciences



TNO Information and Communication Technology



TNO Defence, Security and Safety focuses on:

Defence

- Military operations
- Military equipment
- Command and operational decision making
- Threat and protection
- Education and training

Security and Safety

Combating crime, calamities and terrorism

Aerospace

- Improving safety
- Maritime
 - Shipbuilding







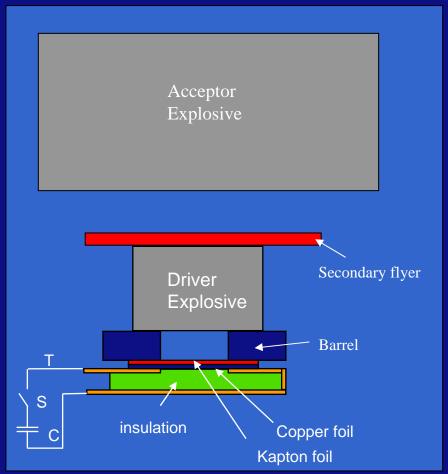
Organisation TNO Defence, Security and Safety





Exploding Foil Initiator Research

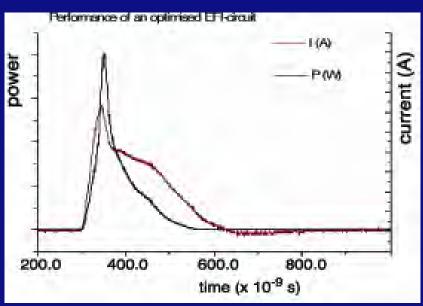
- Electrical circuit
- Exploding foil
- Velocity of the flyer
- Driver Explosive
- Secondary flyer
- Acceptor explosive





Electrical circuit

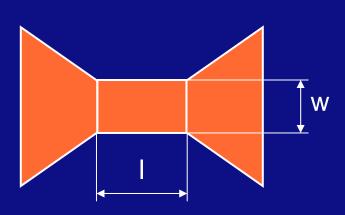
- Optimisation of the circuit
 - -low loss capacitor,
 - -switch,
 - -transmission line
- Development of measuring techniques
- 90% efficiency of energy deposited in the exploding foil (50 % other circuits)

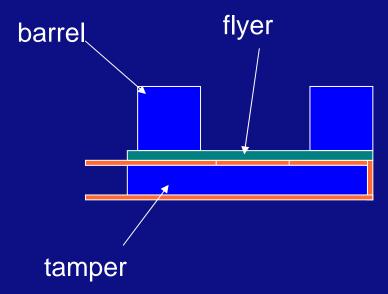




Exploding foil

- Dimension of the foil (length, width, thickness, material)
- Shockwave impedance of the tamper
- Thickness and material of the flyer
- Length and width of the barrel

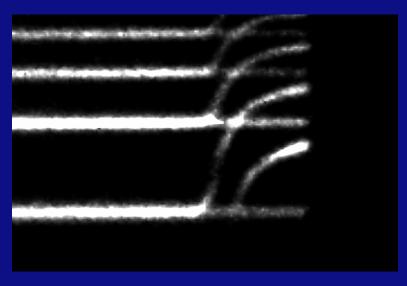


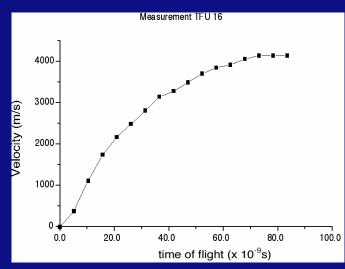




Flyer velocity measurement by F-P Interferometer

- Acceleration of the flyer influenced by:
 - -thickness and material
 - -exploding foil dimensions and material
 - -shockwave impedance of the tamper
- Integrity of the flyer during acceleration
 - -Determination of optimum barrel length







Research on Explosives I

- Recrystallisation of HNS II to HNS IV
- The crystals are more uniform (smaller distribution)
- The length to width to thickness is 10:3:2 a further increase in specific surface area is possible

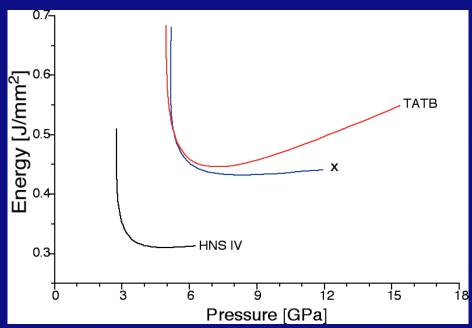






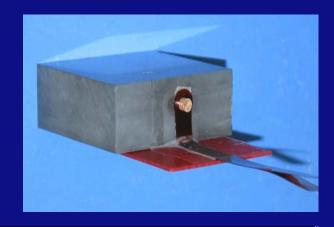
Initiation behaviour of different explosives

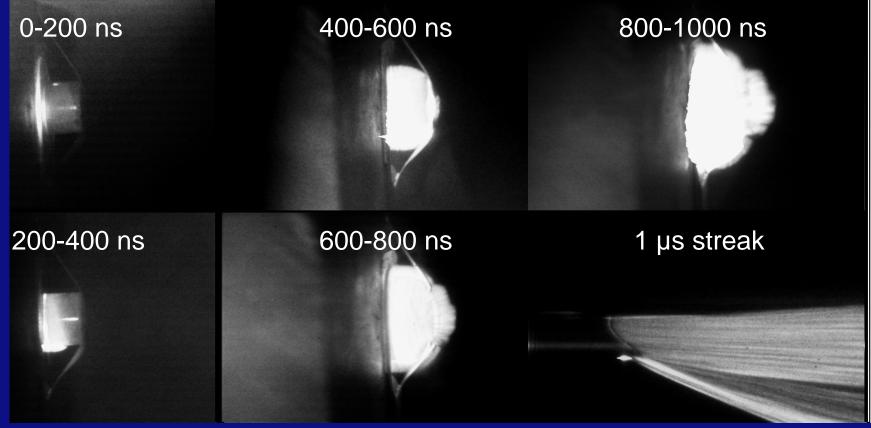
- Different types of explosives
 - HNS IV several brands
 - TATB several grades
 - New explosives
- •Initiation energy depends on flyer thickness and velocity





Initiation of HNS IV pellet

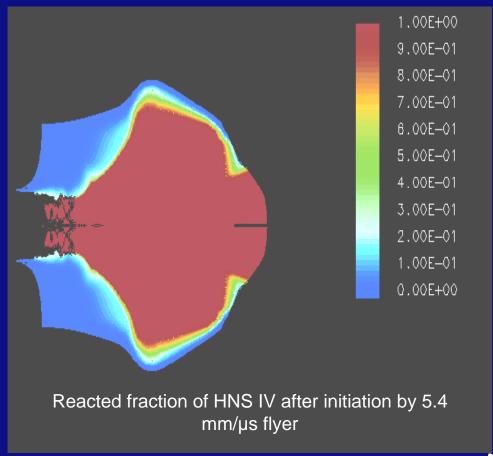






Numerical simulations of flyer impact

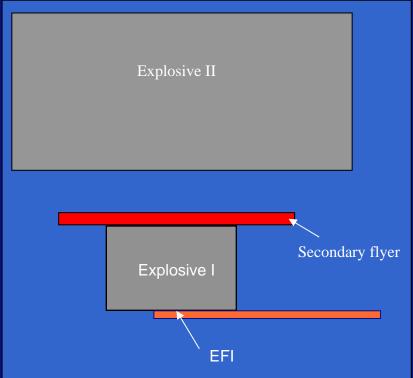
- Lee-Tarver model modified with visco-plastic pore collapse model
- Qualitatively the simulations can explain the experiments





Secondary flyer impact

- Driver explosive (HNS IV, TATB, RDX)
- Confinement of the explosive
- Secondary flyer material:
 - spall strength (attenuator)
 - shockwave impedance
 - size and thickness
- Initiation distance of acceptor explosive

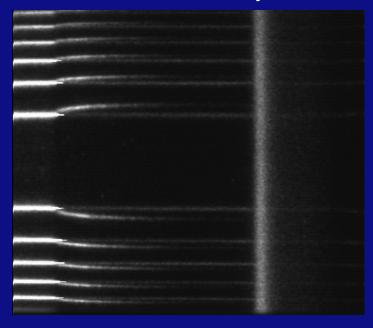


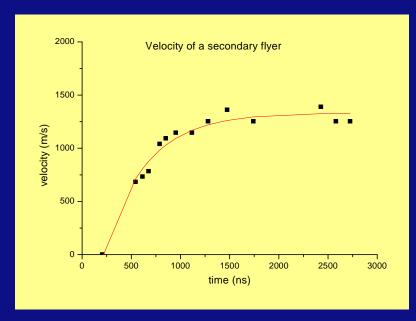


Secondary flyer impact

Acelleration of a 0.25 mm stainless steel flyer by HNS IV Successful initiation of TATB by

- 0.15 mm SS steel flyer
- 0.35 mm mylar flyer
- 0.3 0.5 mm Al flyer







Conclusions

- A very efficient electrical circuit is developed ($\eta = 90\%$)
- With "of the shelf components" small IM compliant EFI-detonators can be build (8 cm³ including HV-supply)
- Combining the EFI with the electronic safety and arming unit with MEMS-technology can make a small and cost effective unit
- The use of secondary flyers makes the detonation train more reliable

Pieter van 't Hof Pieter.vantHof@tno.nl

Wim Prinse Wim.Prinse@tno.nl





50th Annual Fuze Conference Norfolk, VA May 09 – 11, 2006

Introduction of the Multi Option Fuze Artillery (MOFA) DM84 on 120mm Rifled Mortar



JUNGHANS Feinwerktechnik GmbH & Co. KG
Jochen Wagner

***JUNGHANS** Feinwerktechnik



Artillery Howitzer PZH 2000

#JUNGHANS Feinwerktechnik





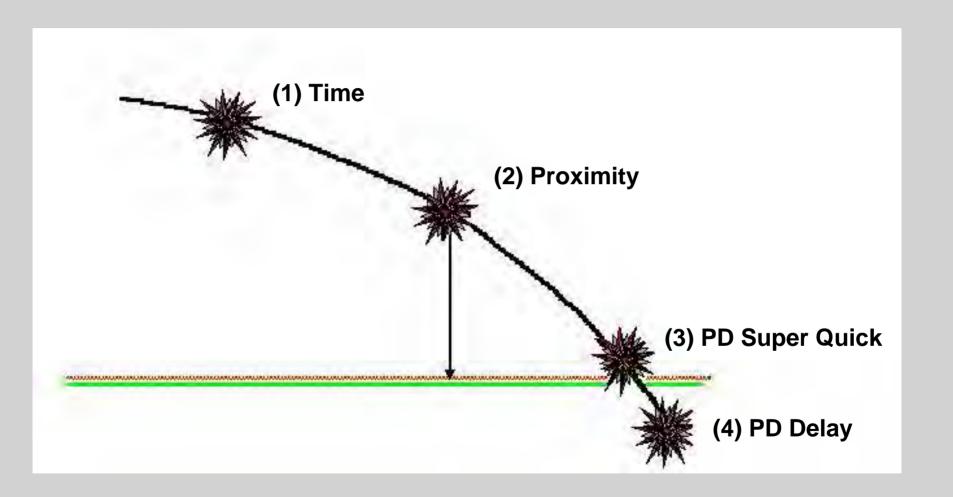
Copyright of the video by





Fuze types mortar / artillery - functioning







DM34, DM34A1 Proximity Fuze





- Function: Proximity,
 Point Detonating SQ or Delay
- Manually Settable
- Not Jamable
- Produced for
 German Armed Forces
 (DM34 in service since 1988,
 DM34A1 in service since 1994)
 Swedish Armed Forces
 (DM34A1-S as ÖFZONAR94 MK in service since 1996)
 Norwegian Armed Forces
 (DM34A1 as BRANRØR PPD MN187 in service since 1997)
- More than 250,000 ea, fielded



DM74 Multi Option Fuze





- Function: Proximity, Time, Point Detonating SQ or Delay
- Inductively Settable
- Overflight Safety T-4
- Not Jamable
- Produced for German Armed Forces (in service since 1997)
 Canadian Armed Forces (as C32 in service since 1998)
 Danish Armed Forces (in service since 2000)
- More than 270,000 ea. fielded

DM84 Multi Option Fuze





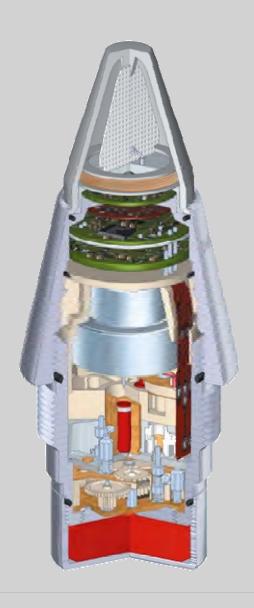
<u>Usage</u>

- on 105 mm / 155 mm high explosive artillery shells
- Field Howitzer 105mm
- Field Howitzer 155mm, 39cal. Barrel
- Self Propelled Howitzer 155mm, 39cal. Barrel
- Self Propelled Howitzer 155mm, 52cal. Barrel
- 120mm Rifled Mortar



DM84 Multi Option Fuze





Further information

- derived from the DM74
- Proximity, Time, PD with and without delay
- two heights of burst (10m / 4m) in PROX mode
- inductive settable (acc. to STANAG)



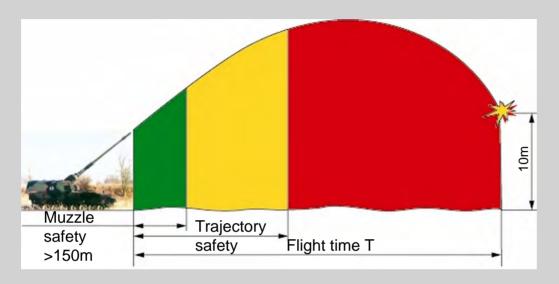


- reserve Battery with S&A Mechanism
- flick-ramming safe
- delivered to the Dutch Armed Forces
- Adapted to be used on 120mm rifled mortars



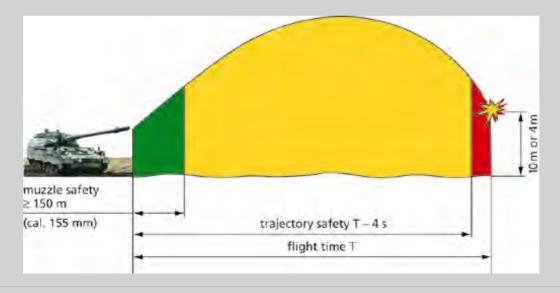
Trajectory Safety JUNGHANS MOFA DM74/DM84





Factory (default) setting

Muzzle Safety >150m (490ft)



Inductive programmed

- Muzzle Safety >150m (490ft)
- Trajectory safety T-4s



120mm Rifled Mortar

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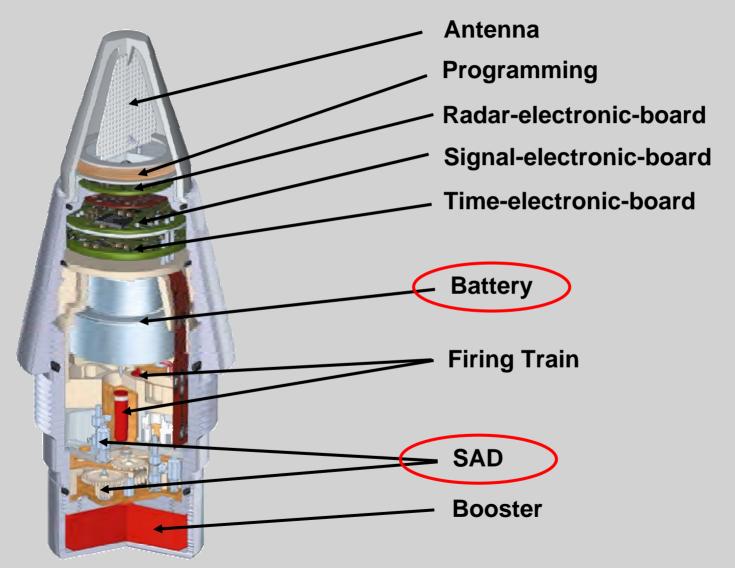






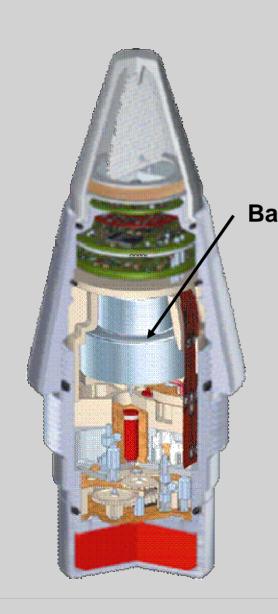
DM84 Multi Option Fuze

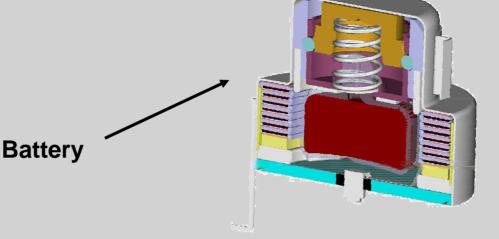




DM84 Multi Option Fuze adaptation



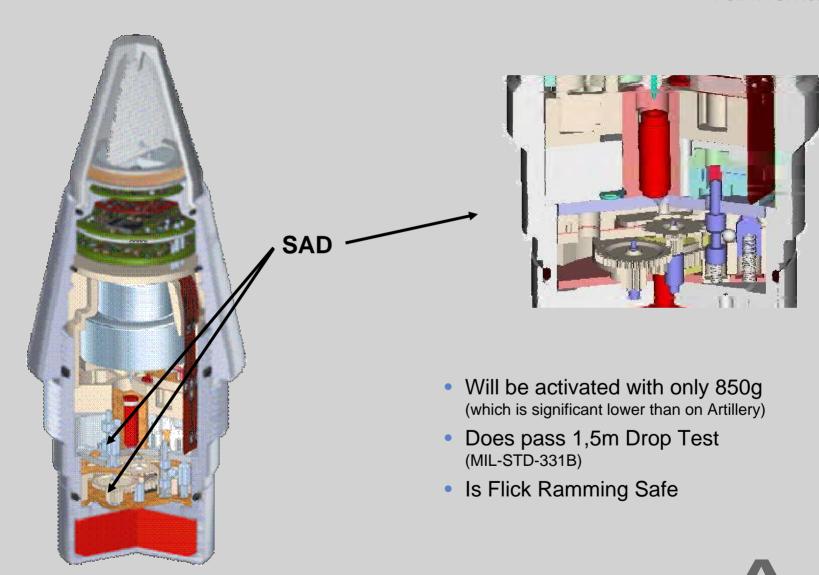




- Will be activated with only 850g (which is significant lower than on Artillery)
- Does pass 1,5m Drop Test (MIL-STD-331B)
- Is Flick Ramming Safe

DM84 Multi Option Fuze adaptation

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DM84 Multi Option Fuze for 120mm Rifled Mortar





Summary

- DM84 offers a more sophisticated use of 120mm rifled mortars and improves the users options and system efficiency
- Using one fuze for artillery and mortar reduces logistics burden
- Training can be standardized
- DM84 is fielded in a NATO country





JUNGHANS Feinwerktechnik GmbH & Co. KG

Thank you for your kind attention!





Providing America Advanced Armaments for Peace and War



ENHANCED PORTABLE INDUCTIVE ARTILLERY FUZE SETTER (EPIAFS)

PRESENTED TO THE NDIA FUZE SYMPOSIUM May 10, 2006



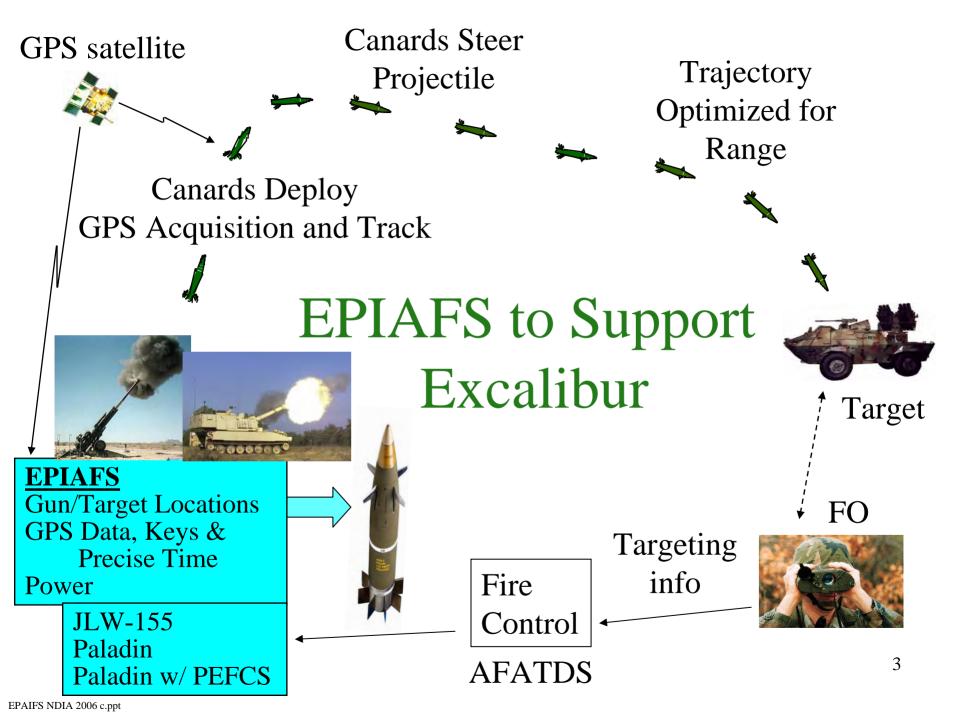






- Sponsor: PM-Excalibur LTC Cole
 - Chris Grassano
 - Mike Burke
 - MAJ Foster
- System: Ray Sicignano
 - Tom Coradeschi
- Platform Integration: Allison Marston
 - Fred Gloeckler
- User: Ft Sill
 - Steve Pearson
 - Bernie Garcia
- Software
 - Andy Leshchyshyn
 - Craig Freed
 - Paul Knors
- Mechanical
 - Jim Hartranft
 - Spencer Hum
 - Jr. Knisley
 - Rob Wood
- Electrical
 - Debbie Calomiris
 - Len Goodman
 - Hai Pham
 - Fred Oliver
 - Mary Labib
 - James Wiltz
 - Tom Walker
 - Jerry Frazier
 - Brent Beauseigneur





EPIAFS SYSTEM

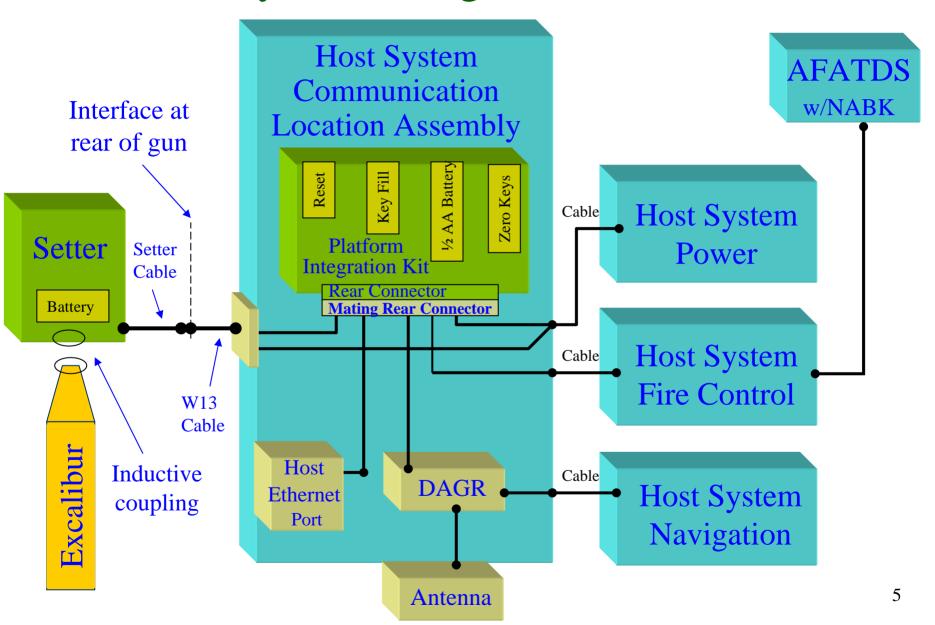
- PLATFORM INTEGRATION KIT (PIK)
 - Single board computer
 - Interface circuit
- SETTER and Cable
- EPIAFS utilizes
 DAGR

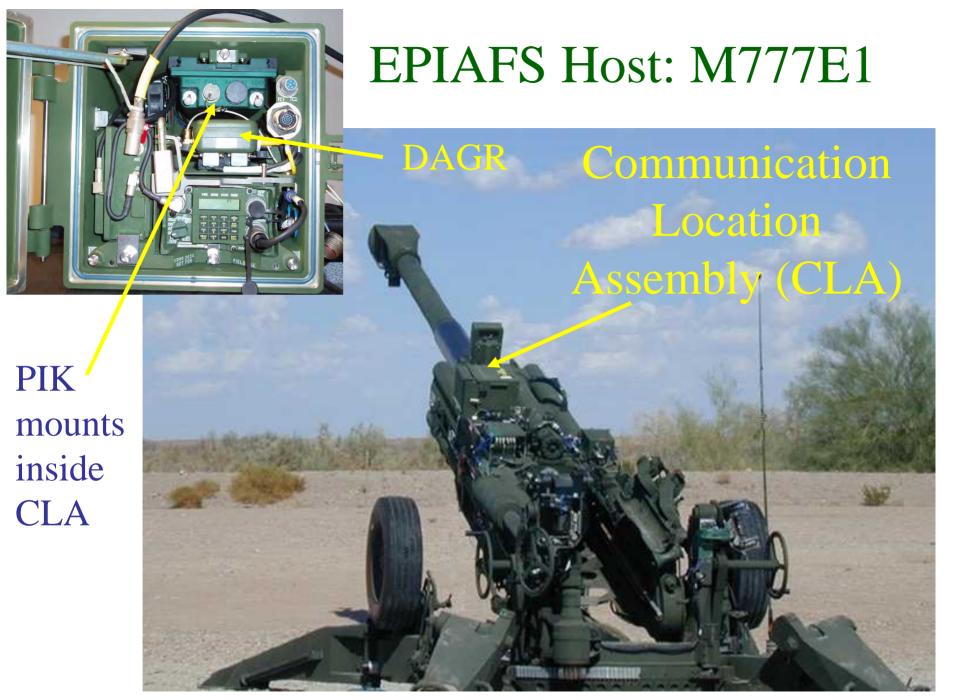




SETTER

EPIAFS System Integrated into JLW155



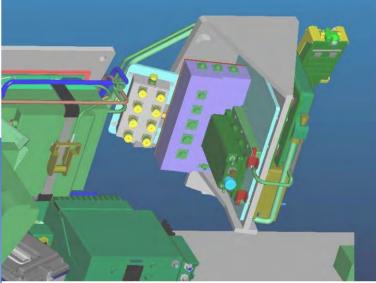


JLW Crew Setting Excalibur GNC



EPIAFS Host: Paladin

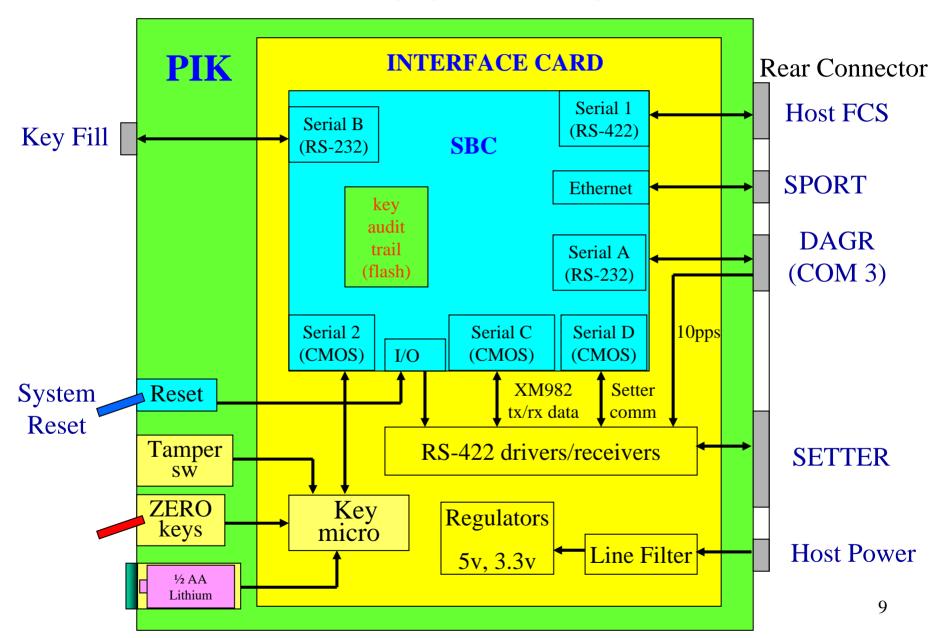




Paladin w/ PEFCS

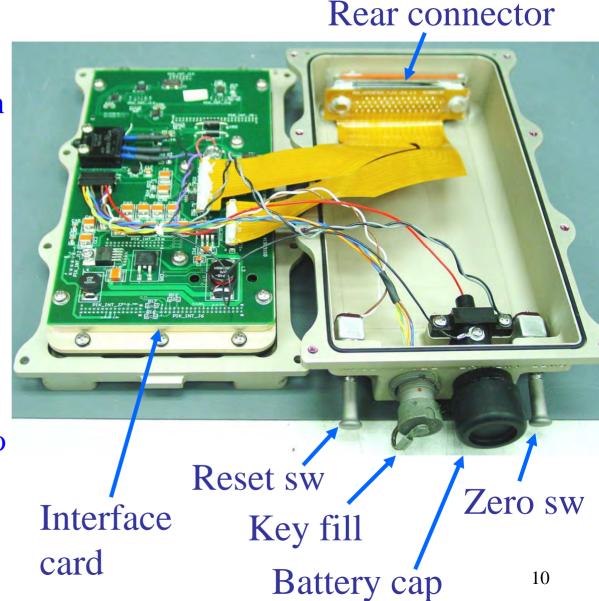


PIK BLOCK DIAGRAM



PIK FUNCTIONS

- Formats and sends all XM982 initialization data and TMP's through Setter
- Passes Standard Fuze
 Data to Setter
- Interfaces with Host system
- Interfaces with Key Loader
- Stores black GPS crypto keys and Audit Trail
- Interfaces with SPORT or MSD

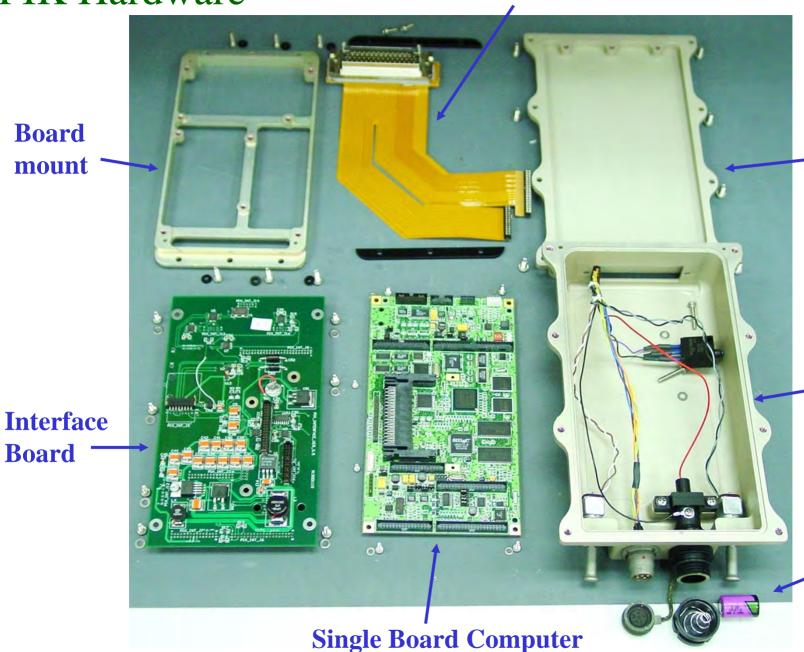


PIK Hardware

Board

mount

Flex & Rear Interface Connector



Cover

Box assembly

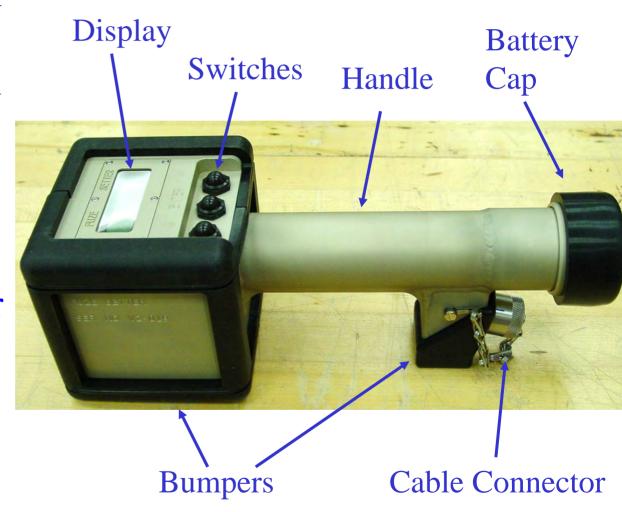
Battery

11

Board

SETTER FUNCTIONS

- Interface with PIK
- Interface with standard fuzes and XM982
- Convert XM982
 data stream to
 power/data format
- Interface with user via 3 switches and LCD
- Un-cabled setting for standard fuzes



SETTER Hardware Board Cage

Box & Handle Assembly



Faceplate Assembly

Battery Contact Assembly **Battery Cap**

3 SETTER MODES

Uncabled

- Acts just like original PIAFS
- Standard Fuze capable



Cabled Manual

- Same functionality as Uncabled
- Receives power externally

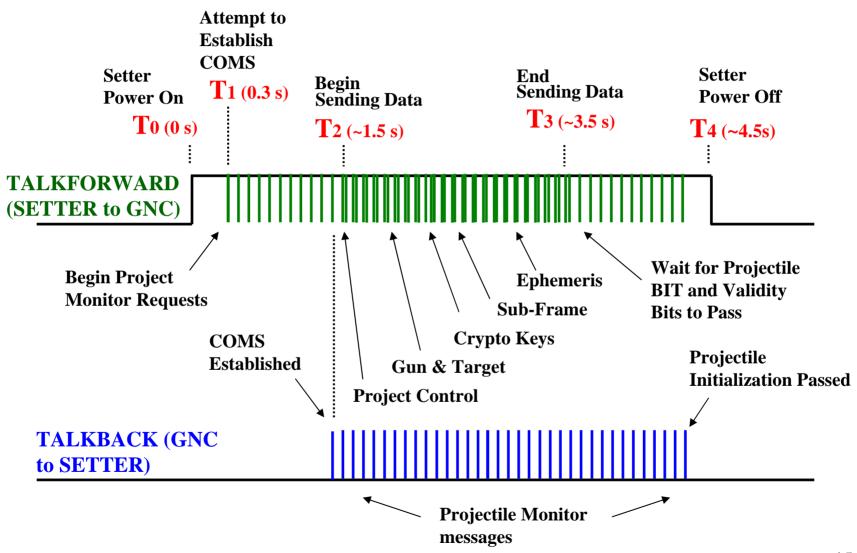
Cabled Remote

- Receives commands from PIK
- Standard and GPS Fuze capable



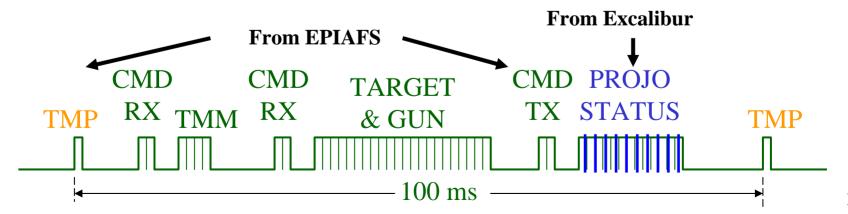


INITIALIZATION TIME-LINE

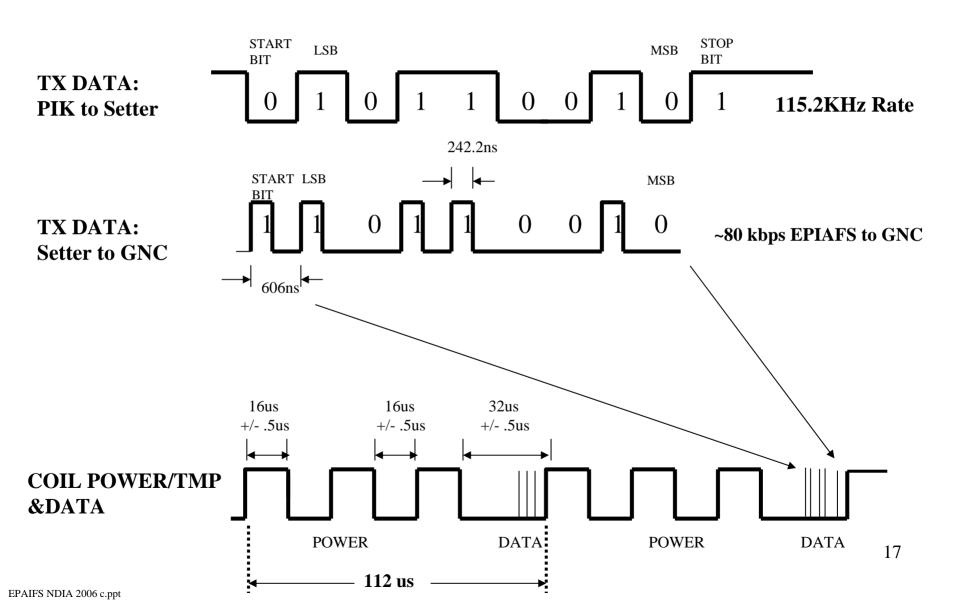


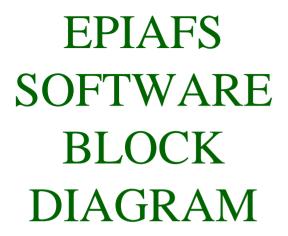
EXAMPLE 100 ms PIK TO PROJECTILE MESSAGE FRAME

- Sense when Time Mark Pulse (TMP) arrives
- Read Time Mark Message from GPS receiver
- Send Time Mark Message to Projectile
- Send Target and Gun data to Projectile
- Request a Status Message from Projectile
- Receive and Process the Projectile Status



Time Multiplexed Power/Data Format





Setter

Display Driver

Control & Diagnostics

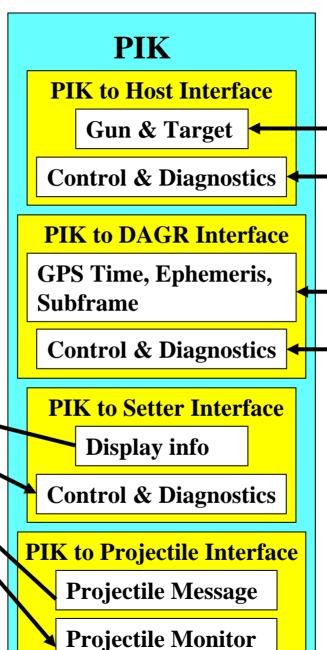
Coil Driver

Inductive Interface

XM982 Projectile

Projectile Monitor

Projectile Message



Host System

Gun & Target

Control & Diagnostics

DAGR

GPS Time, Ephemeris, Subframe

Control & Diagnostics

18

EPIAFS Software Status

• PIK

- Written in C++
- 25,000 lines of code
- Software FQT Ver 2.6

• Setter

- Written in C
- 12,000 lines of code
- Software FQT Ver 2.1











EPIAFS Fabrication



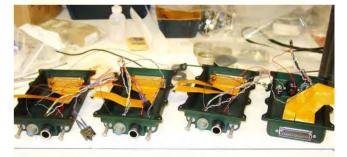








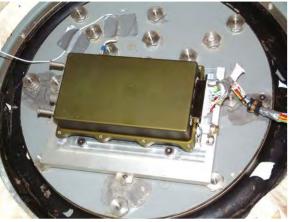






EPIAFS Lab Testing

Shock/vibration













Leak

Temperature

EPIAFS Field Testing

Paladin



Excalibur



Setting Excalibur before firing







Yuma Proving Ground

EPIAFS Laptop Host FCS

EPIAFS ACCOMPLISHMENTS FY06

- Supported development of EPIAFS-Excalibur interface
- Received EPIAFS CONOPS approval for Black Keys from NSA
- Delivered Prototype EPIAFS to PM-CAS
- On-site support at Raytheon of EPIAFS integration
- Delivered laptop based Host Fire Control System to allow early Field testing
- On-site support of Excalibur test firings at YPG
- Supported integration of EPIAFS into Portable Excalibur Fire Control System (PEFCS)
- Delivered Qualification EPIAFS to PM-CAS
- Passed EPIAFS Software Formal Qualification Testing (FQT)
- Supported PEFCS FQT
- Passed DITSCAP
- Authored documents including: Detail specs, Software specs, test plans, system drawing tree, ICD's, CONOPS
- Supported Excalibur, JLW, EPIAFS, and PEFCS E3 testing at WSMR
- Implemented Setter casting to reduce EPIAFS UPC

PLANS

- Complete EPIAFS Qualification Build & Test
- Field units to PEFCS to support Excalibur Early Fielding
- Update EPIAFS TDP
- Support EPIAFS integration into JLW-155 and Paladin
- Support EPIAFS functional integration into NLOS-C
- Support Contractor First Article Build



